Aviation Week

Including **Space Technology**

75 Cents

A McGraw-Hill Publication

February 2, 1959

Sikorsky Broadens VTOL Research

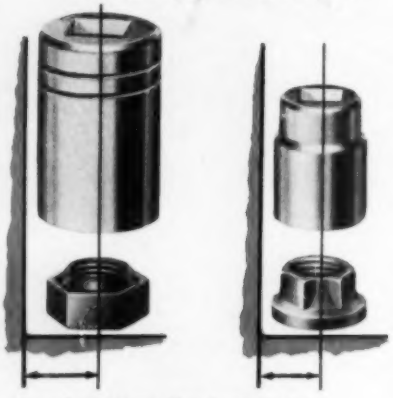
•

Goldstone Space Probe Tracking Station

NEW KAYLOCK H-14!

COMPARE WRENCH ACCESS

Standard Hex vs New H-14



See how new Kaylock H-14

- **Saves weight and space**
- **Brings bolt closer to load center line**
- **Permits narrower flanges**

***The Kaynar self-locking principle, of which the Kaylock Ellipse is an example, is patented (#2,816,591).**

It's another pace-setting development by Kaynar, who pioneered the first lightweight, self-locking nuts for airframes, missiles, jet engines and electronics.

The new Kaylock H-14 offers these exclusive advantages:

- 20% to 42% lighter than Kaynar's original H-10 hex nut series—smaller envelope dimension
- Tensile strength rated for 160,000 PSI bolts
- Uses two-size smaller sockets than for Standard AN and NAS nuts
- Nut and bolt can be moved closer to load center line
- Patented* Kaynar thin-wall, resilient self-locking device assures uniform locking torque
- Also available in A286 corrosion-resistant steel for 900°F

Write today for special brochure containing full details and specifications of the new Kaylock H-14 . . . or call your Kaynar sales engineer.

KAYLOCK®
All-Metal Self-Locking Nuts

KAYNAR MFG. CO., INC.—KAYLOCK DIVISION • World's largest and oldest manufacturer of lightweight, all-metal self-locking nuts
Home office and plant: Write Box 2001, Terminal Annex, Los Angeles 54. Branch offices, warehouses and representatives in Wichita, Kansas; New York, New York; Atlanta, Georgia. Canadian Distributor: Abercorn Aero, Ltd., Montreal, Quebec.

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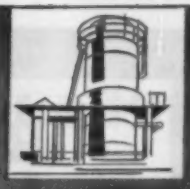

Foresight with a **wallop!**

Foresight which saw the coming of the Space-and-Missile Age enabled Goodyear Aircraft Corporation to begin construction—*more than ten years ago*—of what is today one of the most advanced and largest integrated rocket engine case facilities in the nation.

Furnaces—among the largest ever built for the task—spawn these exacting space-conquering units. Experienced technicians, backed by batteries of test equipment, control the quality of the materials—insure the soundness of each weld—maintain tolerances to thousandths of an inch.

This foresight, these skills, this equipment have made Goodyear Aircraft the birthplace of more large-size rocket engine cases than any other producer.

For more information on this completely integrated facility, write Goodyear Aircraft Corporation, Dept. 916AU, Akron 15, Ohio.

ROCKET ENGINE CASES—One of the Prime Capabilities of

GOODYEAR AIRCRAFT

Plants in Akron, Ohio, and Litchfie... Park, Arizona

RADAN® SYSTEMS

ground speed & drift angle any time, anywhere, any weather

One look and the pilot KNOWS. In a glance he reads actual ground speed and drift angle, displayed on his flight panel – automatically and continuously.

The system operates entirely without ground aid or celestial fix.

RADAN is the result of GPL's harnessing of Doppler for air navigation—an achievement comparable in magnitude to the breaking of the sound barrier.

...and now for everyone

The wraps are off RADAN! The civilian counterpart of GPL's famous military Doppler auto-navigators, is ready and available *now* – for anyone and everyone!

RADAN Systems have behind them millions of miles of experience in transcontinental, oceanic and polar flights . . . save precious time and fuel . . . provide a priceless margin of safety.

- **RADAN** – accurate: within 1% for ground speed, within ½° for drift angle
- **RADAN** – small: 4.4 cu. ft.–light: 89 lbs.
- **RADAN** – operates without ground or celestial aids
- **RADAN** – virtually maintenance-free

Now in quantity production, RADAN Systems are manufactured by GPL, who developed and is the nation's leading producer of Doppler air navigation systems. Address inquiries to: General Precision Laboratory Incorporated, Pleasantville, New York.

GPL — GENERAL PRECISION LABORATORY INCORPORATED

ENGINEERS – GPL achievements have opened up some unusual research and development opportunities. Send resumé to Personnel Manager.

AVIATION CALENDAR

Feb. 10-March 2—Meeting on Short Range Navigational Aids, International Civil Aviation Organization, International Aviation Bldg., Montreal, Canada.

Feb. 12-13—1959 Solid State Circuits Conference, sponsored by Institute of Radio Engineers' Professional Group on Circuit Theory, American Institute of Electrical Engineers' Committee on Electronics and University of Pennsylvania, Phila., Pa.

Feb. 12-13—Computer and Data Processing in Industry, conference for manufacturing and engineering management. Purdue University, Lafayette, Ind.

Feb. 21-22—13th Annual Pacific Coast Mid-Winter Soaring Championships, Torrey Pines Gliderport, San Diego, Calif.

Feb. 23-26—Third Annual Symposium on Thermal Properties, Purdue University, Lafayette, Ind. Sponsor: Heat Transfer Division of American Society of Mechanical Engineers.

Feb. 26-March 1—1959 Engineering Exposition, Balboa Park, San Diego, Calif. Address inquiries to: 422 Land Title Bldg., San Diego, Calif.

March 3-5—1959 Western Joint Computer Conference, sponsored by Institute of Radio Engineers, American Institute of Electrical Engineers and Assn. for Computing Machinery, Fairmont Hotel, San Francisco, Calif.

March 5-6—Flight Propulsion Meeting (classified), Institute of the Aeronautical Sciences, Hotel Carter, Cleveland, Ohio.

March 5-7—Western Space Age Conference and Exhibit. For information: Domestic Trade Dept., Los Angeles Chamber of Commerce, 404 South Bixel St., Los Angeles 54, Calif.

March 8-11—Gas Turbine Power Conference and Exhibit, Netherlands-Hilton Hotel, Cincinnati, Ohio. Sponsor: American Society of Mechanical Engineers.

(Continued on page 6)

AVIATION WEEK Including Space Technology

February 2, 1959

Vol. 70, No. 5

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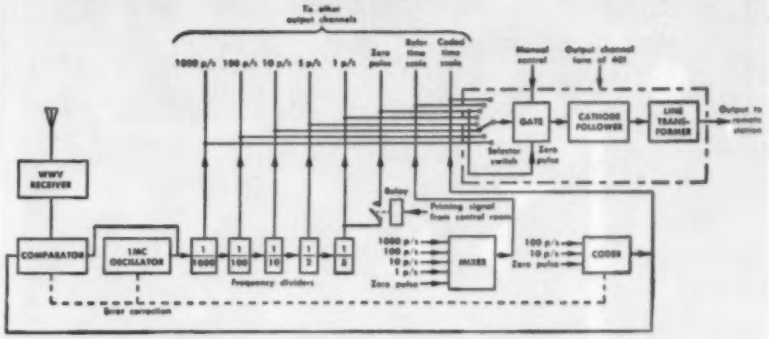
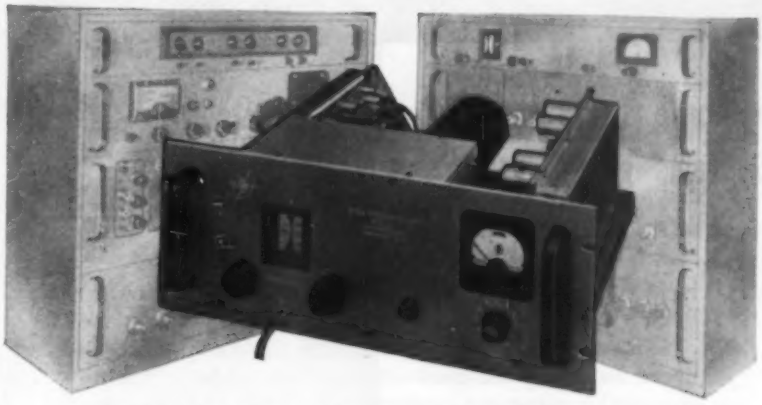
AN INTEGRATED TIMING SYSTEM FOR TRACKING AND CONTROL OF MISSILES



Schematic diagram of Central Timing Station



The Hycon Eastern Integrated Timing System, when used as a central station timer, meets the requirements of most range instrumentation with one comprehensive unit. At pre-programed times during the shoot, time markers are supplied to recording instruments and switching pulses are supplied to recording and control instruments located in remote slave stations.

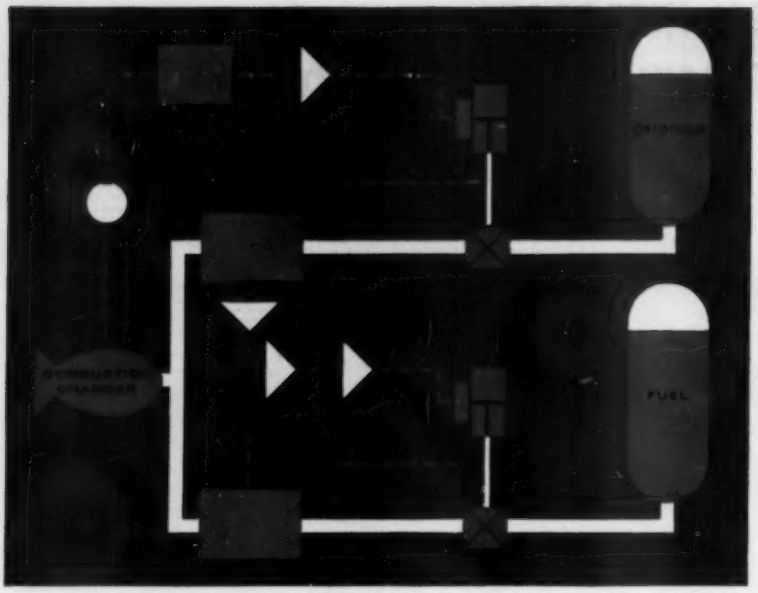
At the heart of the Timing System is the Hycon Eastern Ultra Stable Oscillator with guaranteed stability of one part in 10^9 and even greater stability in actual practice. A WWV Receiver corrects for drift error of the time base oscillator over long time periods and a time scale is available with resolutions accurate to 1 microsecond

Solar or sidereal time is displayed visually and is available for both input to automatic computers and as an index to data being recorded during the test run. Capable of operating anywhere in the world, this system is also suited for astronomical measurements and navigation systems. Write for Bulletin TS-00.

Tomorrow's Timing Systems . . . Today

HYCON EASTERN, INC.

75 Cambridge Parkway Dept. W Cambridge 42, Mass.



In static rocket engine testing . . . CompuDyne Control Systems give greater scope and more useful data

The ability to handle severe transients and to program rocket engine testing on a dynamic basis has made the CompuDyne Rocket Fuel Control System extremely important today.

Oxidizers and high-energy fuels are accurately proportioned and fed to the combustion chamber under precisely controlled flow-pressure conditions.

Steady-state controllability is within close limits but, more important, broad programming within a single run is now practical. Stabilization time between programmed set points may be less than one second. Errors are fully predictable.

The advantages of this complete, packaged system are simple enough: more data faster; more test points per run, more runs per day . . . and with greater accuracy. Ullage volume requirements are minimized and start-up is appreciably simplified.

Similar techniques and a well-founded knowledge of cryogenic materials are used to test rocket engine accessories such as turbo pumps, gas generators and valves.

Complete details await your letter, wire or telephone call.

CompuDyne Control is a trade-name of cdc control services, Inc.

For Test Facilities . . . Typical CompuDyne Control Systems

Aircraft Engine & Components
Aircraft Accessories
Fuel System Components
Blowdown Wind Tunnel
Continuous Wind Tunnel
Dynamic Structural Loading
Altitude Chamber
Compressor Surge

Representatives in major cities

cdc control services, inc.

401 S. Warminster Road, Hatboro, Pennsylvania

S.A. 1059

AVIATION CALENDAR

(*Continued from page 5*)

March 9-12—Aviation Division Conference, American Society of Mechanical Engineers, Statler-Hilton Hotel, Los Angeles.

March 10-11—Third Annual Shock Tube Symposium, Old Point Comfort, Ft. Monroe, Va. For details: Armed Forces Special Weapons Center, Kirtland AFB, Albuquerque, N. M. Attn.: SWRS R. R. Birnkoff.

March 16-20—11th Western Metal Exposition and Congress, American Society for Metals, Pan Pacific Auditorium and Ambassador Hotel, Los Angeles, Calif.

March 23-25—Flight Testing Conference, American Rocket Society, Daytona Plaza Hotel, Daytona Beach, Fla.

March 23-26—National Convention, Institute of Radio Engineers, Coliseum and Waldorf-Astoria Hotel, New York, N. Y.

March 25-27—16th Annual Conference, Pacific Coast Section of the Society of the Plastics Industry, Hotel del Coronado, San Diego, Calif.

March 31-Apr. 2—Polytechnic Institute of Brooklyn's Ninth International Symposium. Subject: Millimeter Waves. Auditorium, Engineering Societies Bldg., New York, N. Y. Cosponsors: Department of Defense Research Agencies and Institute of Radio Engineers.

March 31-Apr. 3—National Aeronautic Meeting, Society of Automotive Engineers, Hotel Commodore, New York, N. Y.

Apr. 2-3—Conference on Electrically Exploded Wires, sponsored by the Thermal Radiation Laboratory of the Geophysics Research Directorate of the Air Force, Cambridge Research Center, Somerset Hotel, Boston, Mass.

Apr. 5-10—1959 Nuclear Congress, Municipal Auditorium, Cleveland, Ohio. For information: Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

Apr. 7-10—1959 Welding Show and 40th Annual Convention, American Welding Society, International Amphitheatre and Hotel Sherman, Chicago, Ill.

Apr. 12-19—Air Force Assn's World Congress Flight, Las Vegas, Nev.

Apr. 18-22—Annual Meeting, American Society of Tool Engineers, Schroeder Hotel, Milwaukee, Wis.

Apr. 21-22—Spring Technical Conference on Electronic Data Processing, Cincinnati Section of the Institute of Radio Engineers, Engineering Society Bldg., Cincinnati, Ohio.

Apr. 22-24—1959 Annual Meeting, Institute of Environmental Engineers, LaSalle Hotel, Chicago, Ill.

Apr. 30-May 1—Controllable Satellites Conference, American Rocket Society, Massachusetts Institute of Technology, Cambridge, Mass.

May 4-6—National Aeronautical Electronics Conference, Institute of Radio Engineers, Biltmore Hotel, Dayton, Ohio.

May 4-7—Fifth Annual Flight Test Instrumentation Symposium, sponsored by the Instrument Society of America, Seattle Section, Olympic Hotel, Seattle, Wash.

May 5-7—Spring Meeting, International Scientific Radio Union, Willard Hotel, Washington, D. C.

June 12-21—23rd French Air Show, Le Bourget, Paris, France.

New NASHVILLE Division

Structures for tomorrow's aircraft and missiles

To make ready for the future, Avco Manufacturing Corporation has created a new division at its Nashville plant devoted to design, development and production of aircraft and missile structures and assemblies.

Avco's new Nashville Division (formerly a part of the Crosley Division) boasts an enviable 17-year record of building components for some of the country's most important aircraft, including the B-52, B-47 and B-36.

Today it produces components for these aircraft:

Convair 880 jet airliner—horizontal and vertical stabilizer; wing tip, leading and trailing edges and flaps.

C-130 Hercules transport—complete empennage.

F-102 Delta Dagger—wing trailing edge.

F9F Cougar—horizontal stabilizer, flaperons and flaperettes.

Looking ahead, the Nashville Division has prepared itself to contribute to the Mach 3 aircraft and Mach 10 missiles that soon will go into production as part of the nation's defense effort.

The Nashville Division's skilled personnel have demonstrated their know-how in producing Avcomb, contoured stainless steel honeycomb panels. They long ago proved themselves in the production of aluminum honeycomb structures, and other advanced manufacturing techniques, such as metal bonding and chemical milling.

Avco/Nashville:
proven . . . ready for tomorrow

For further information, write: General Marketing Manager—Structures, Nashville Division, Avco Manufacturing Corporation, Nashville, Tennessee.

Avco / Nashville

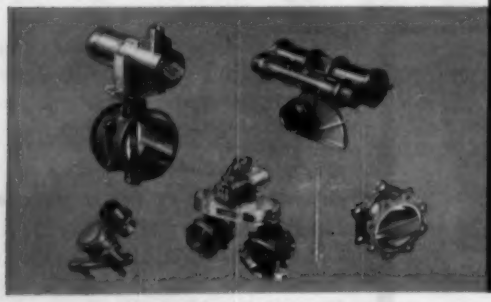
THE MARK OF QUALITY

BARBER COLMAN

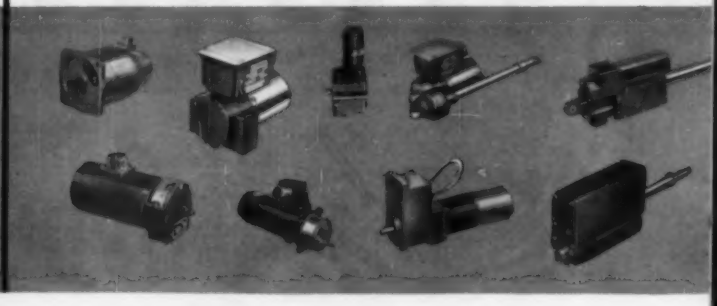
Barber-Colman SYLC Actuator undergoing altitude chamber test

Aircraft and

AIR VALVES — A wide variety of electrically and pneumatically operated air valves for temperature and pressure-control applications. Butterfly, check, poppet, slide, and automatic drain types.

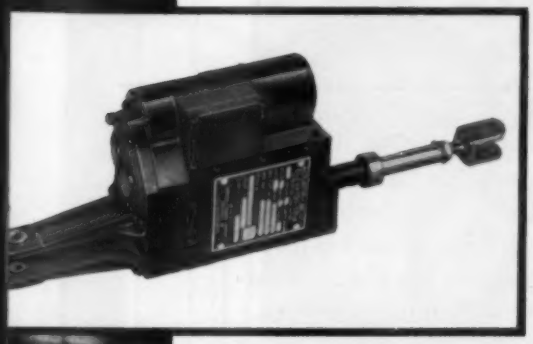


ACTUATORS — Rotary and linear types featuring a wide range of gear reductions switching and mounting details. Available either as standard units or special design to fit various applications. Designed to applicable military specifications.



WHY . . . . . If it's Barber-Colman, it's better

designed for precision applications, new SYLC actuator meets the most exacting specifications on every count



Indicative of the Barber-Colman ability to build aircraft and missile controls that meet extreme requirements is this special, lightweight SYLC linear actuator. Designed for a high-speed jet fighter elevator trim application, it passes these specifications:

- Servo mode response rate
- Low backlash — less than .005"
- Small differential ball detent clutch (90 lb carry — 110 lb full slip)
- Less than 40 milliseconds' stopping time
- Position indication — .002" resolution
- Ambient temperature range −65°F to +275°F
- Travel limit and centering switches
- Nonjamming positive stops
- Radio noise filter
- Thermal overload protection
- Weight 3.4 pounds

The Barber-Colman line of compact SYLC linear actuators is designed to handle loads in excess of 150 pounds and withstand 20 G vibration. They feature low backlash and high positioning accuracy . . . optional radio noise filter . . . adjustable limit switches . . . optional centering switches . . . permanent magnet d-c, split-series d-c, or 400 cycle a-c drive motors . . . dynamic braking and thermal overload protection if desired. For information on use of these actuators on your applications, call the Barber-Colman engineering sales office nearest you: Los Angeles, Seattle, New York, Boston, Baltimore, Fort Worth, Montreal, Rockford, or write direct to address below for literature.

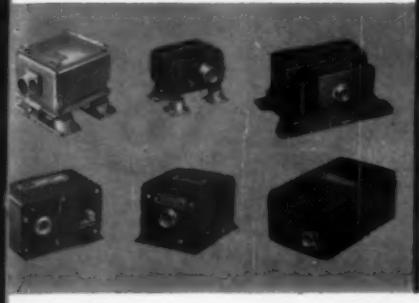
BARBER-COLMAN COMPANY

Dept. B, 1422 Rock Street, Rockford, Illinois

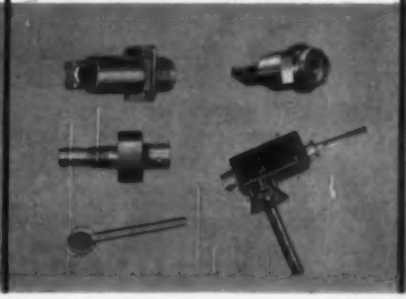
Aircraft Controls • Electrical Components • Small Motors • Automatic Controls • Industrial Instruments • Air Distribution Products • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

Missile Accessories

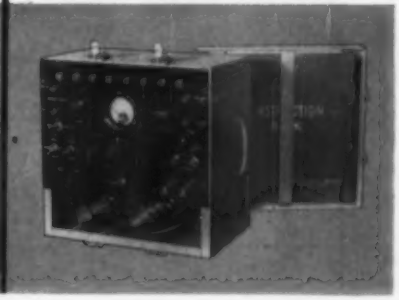
TEMPERATURE CONTROL AND POSITIONING SYSTEMS — Electronic, magnetic amplifier, transistor, or relay-controlled systems designed to meet your requirements.



TRANSDUCERS AND THERMOSTATS — Units for sensing compartment, duct, windshield temperatures. CEDAC system senses, controls temperature and/or airflow in ducts.



TEST EQUIPMENT — Compact electrical test units for quickly checking all components of a Barber-Colman control system installed in an aircraft. Special units for checking many electrical systems.



XV

This is the fifteenth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Boron and Its Effects in Alloy Steels

Boron is a nonmetalic element of which this country has a plentiful supply. In its natural or unprocessed state it occurs only in combination, as in borax, etc. Pure boron is a gray, extremely hard solid with a melting point in excess of 4000 deg F.

This element is used in steel for one purpose only—to increase hardenability; that is, to increase the depth to which the steel will harden when quenched. Its effective use is limited to sections whose size and shape permit of liquid quenching. Only a few thousandths of 1 pct is ordinarily added, and boron steels are evaluated by increased hardenability rather than chemical content. A number of alloys, including several grades of ferroboron, are available for adding boron to steel.

Boron intensifies the hardenability characteristics of other elements present in the steel. It makes possible a considerable degree of alloy conservation when used with steels containing small amounts of alloying elements. However, since it readily oxidizes at high temperatures, some steelmakers prefer a melt with relatively low boron content and relatively high contents of other elements that protect the boron from oxidation.

It should be noted that boron is very effective when used with low-carbon alloy steels; but its effect is reduced as the carbon increases. When the carbon content is above 0.60 pct, the use of boron is not suggested, the exception being the "case" in those steels that are carburized.

Boron steels often require closer temperature control in heat-treatment than do some of the other alloy analyses; but aside from this they present no special problems. Their cold- and hot-working properties are considered at least equal to those of ordinary alloy steels. In cases where boron makes possible a lower alloy content, improved machinability frequently results.

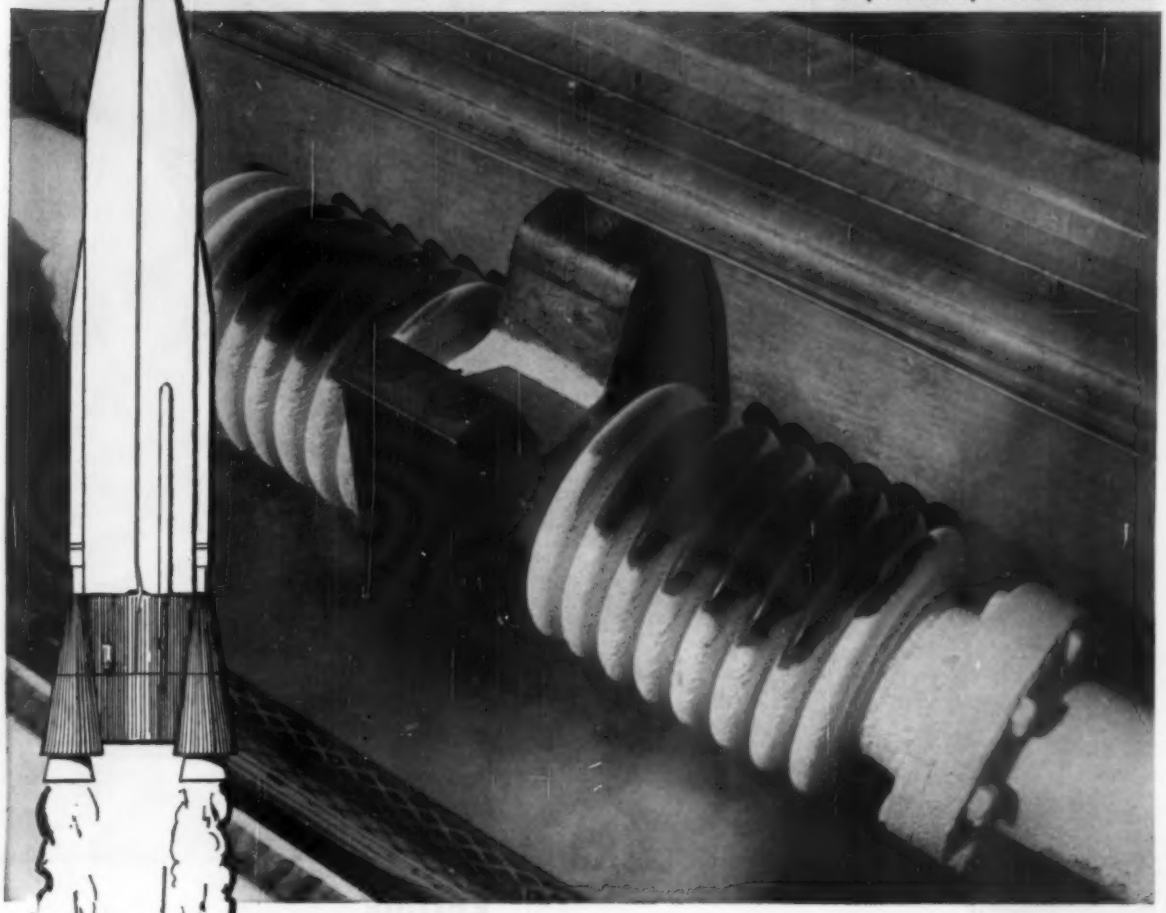
If you would like to know more about boron and its effects in alloy steels, you are invited to consult with Bethlehem's metallurgical staff. Our technicians will gladly give you all the information you need, and will work closely with you in every respect. And when it is time to replenish supplies of steel, remember that Bethlehem manufactures the full range of AISI standard alloy grades, as well as special-analysis steels and all carbon grades.

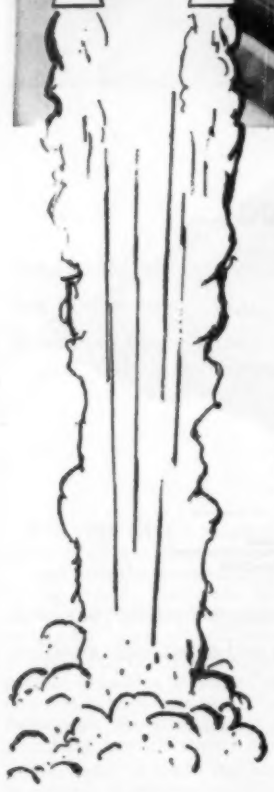
BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

For temperatures of –300F and below!





Sola-Flex® joints provide safe, easy handling of liquid missile fuels

LIQUID OXYGEN, used in Convair's *Atlas* ICBM, requires the very best handling know-how—and equipment. These rugged Sola-Flex expansion joints are in use on Convair's fuel test facility at San Diego, California. Made from 321 stainless, the 6 in. double-end anchor-base unit handles over 5 in. of axial movement in a LOX test line.

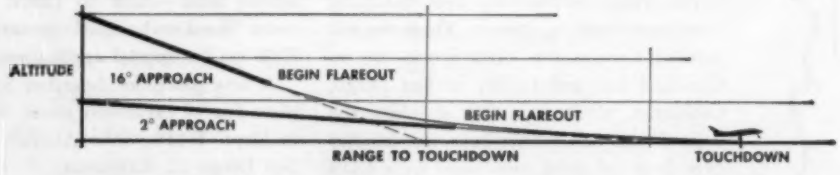
Solar manufactures the most comprehensive line of bellows and expansion joints in the world. They are made from a wide variety of stainless and high alloys for important nuclear, missile and industrial applications—in sizes ranging from ½ in. to 35 ft in diameter. They are built for service from –320F to 1200F. And they tame "hard-to-handle" pressures up to 3500 psi for special applications.

A new pamphlet describes Solar's complete line of expansion joints. Write for it to Dept. F-118, Solar Aircraft Company, San Diego 12, California.

SOLAR
AIRCRAFT COMPANY
SAN DIEGO
DES MOINES

getting back is important, too...

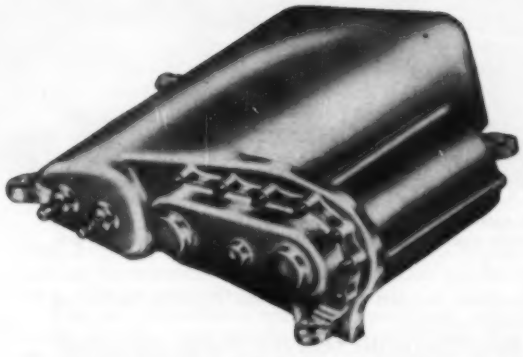
...With costly airplanes and missiles, the descent is just as important as the flight. Autonetics' all-weather AUTOFLARE (automatic flare control system) takes over at sinking rates as high as 100 feet per second and airspeeds as great as 250 knots... makes safe zero-zero landings truly automatic. Entirely self-contained, AUTOFLARE requires no data links or radio commands.



AUTOFLARE—adaptable to a variety of manned or unmanned airframes containing autopilots—has been proven by more than 1000 successful AUTOFLARE-controlled landings of jet fighters and supersonic missiles.

Autonetics
A DIVISION OF NORTH AMERICAN AVIATION, INC.
Downey, California

Stratopower can't afford to stay in step- We have to stay ahead... years ahead in hydraulic development



STRATOPOWER keeps years ahead in hydraulic development by advanced theorizing, advanced research and testing ... and with the most advanced precision production facilities in the world. Here, for example, is a STRATOPOWER Hydraulic Package being built for a new missile project ... calling for "years ahead" hydraulic technology.

STRATOPOWER Hydraulic Packages and Systems are perfect examples of being "made for each other." They contain everything you need, including specified performance. Reservoirs, accumulators, valves, pumps, motors and even plumbing, are all mated into a smoothly functioning unit.

The heart of these Packages and Systems is the constant or variable displacement STRATOPOWER Hydraulic Pump. Models are available to operate dependably up to 450° F., and at exceptionally high speeds.

The advanced designs of STRATOPOWER Hydraulic Pumps are made practical by precision manufacturing that makes watchmakers' standards seem clumsy by comparison. 50 millionths of an inch are tolerances found in production models. Specify STRATOPOWER Pumps, Motors, Packages or Systems, and you, yourself, take a giant step ahead of the competition.

WRITE TODAY: ***See how your hydraulic power application is best fulfilled by STRATOPOWER Hydraulic Pumps, Packages and Systems ... it's a step in the right direction!***

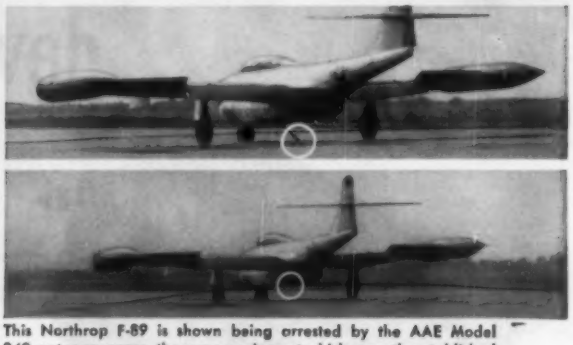
WATERTOWN DIVISION
THE NEW YORK AIR BRAKE COMPANY
STARBUCK AVENUE • WATERTOWN • N. Y.

The *AAE* Water Squeezer...

the most thoroughly tested, most widely used ground-based braking system

- Low initial cost
- Economical operation
- Always on duty
- Reliable
- No adjustments
- No triggers
- Minimum maintenance
- Rapid re-setting

The water squeezer engine, used with either barrier or tail hook, absorbs energy by pulling pistons through fluid-filled tubes as shown in this drawing.



This Northrop F-89 is shown being arrested by the AAE Model 340 water squeezer, the same equipment which recently established a world record by stopping a 34,000 lb. aircraft load at 185 m.p.h.

All American's water squeezer arresting engine is the most thoroughly tested, most widely used runway absorber in the world. As the basic unit of ground-based braking systems installed to eliminate airport overrun accidents, the engine has the simplicity, reliability and consistency of operation needed to insure the highest degree of runway safety.

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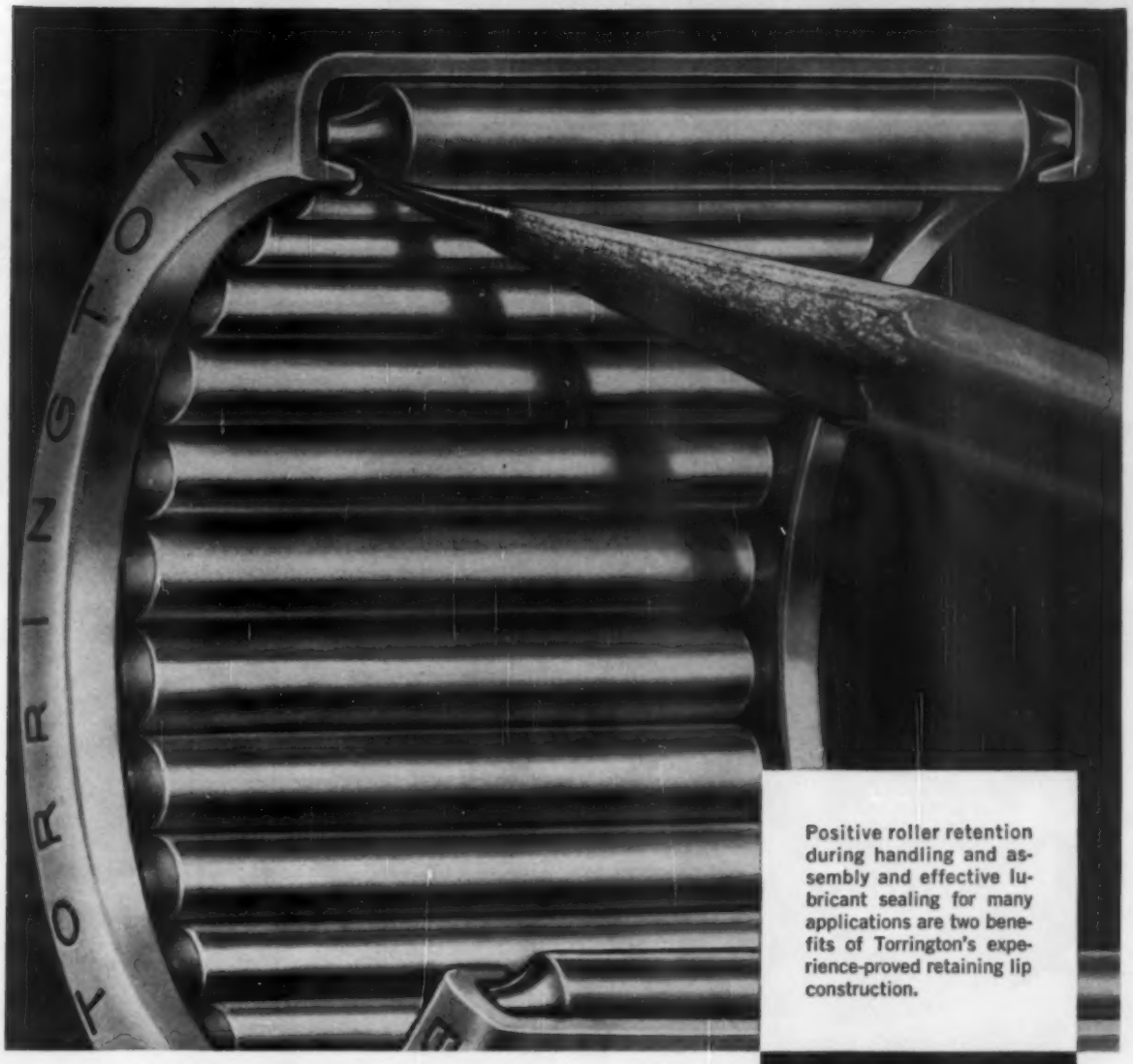
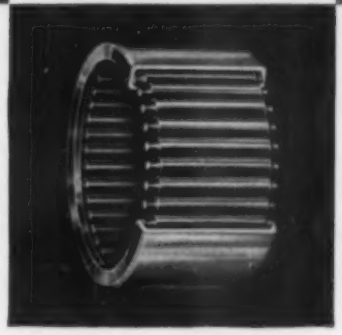


Positive roller retention during handling and assembly and effective lubricant sealing for many applications are two benefits of Torrington's experience-proved retaining lip construction.



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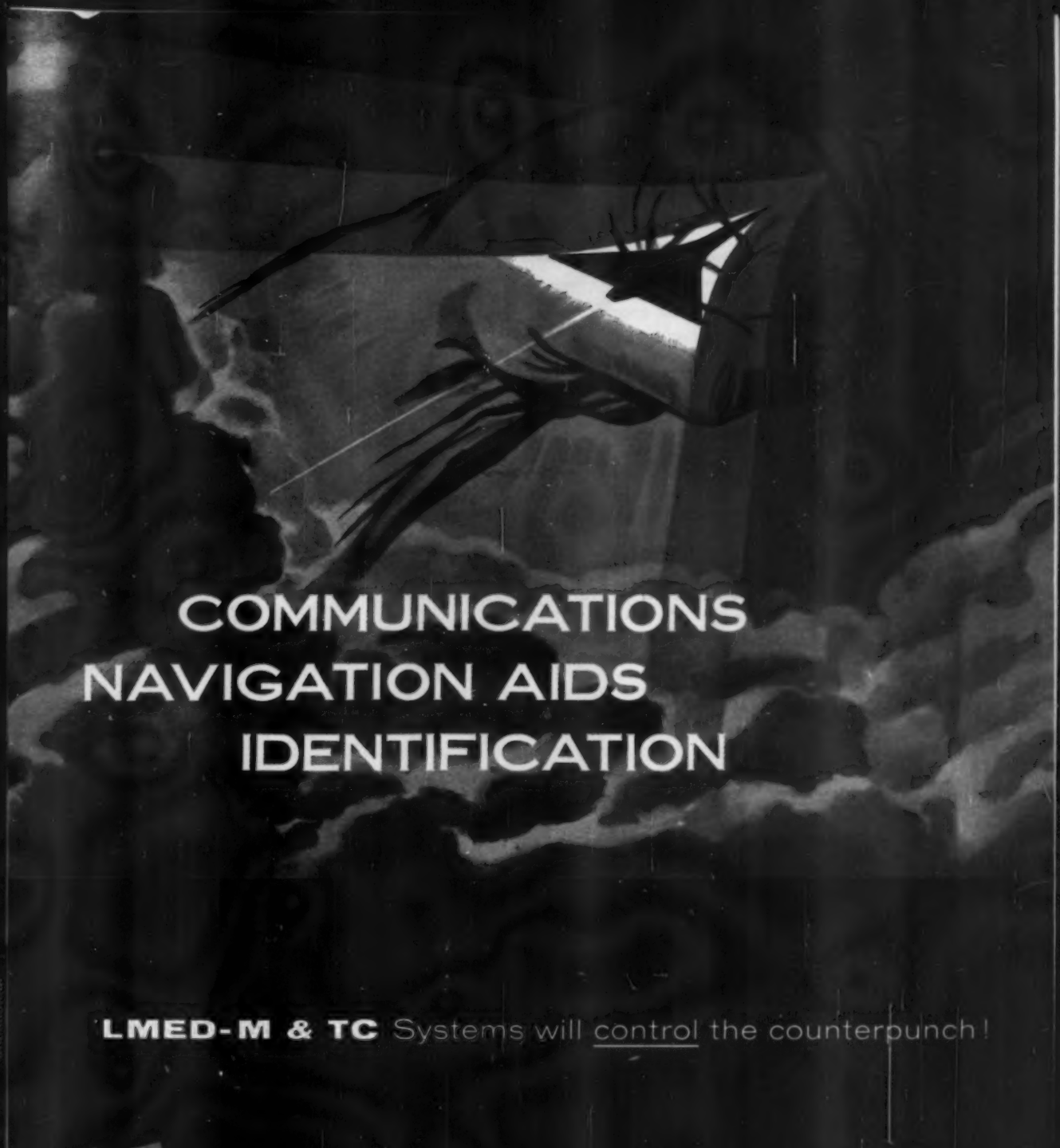

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NASA Plans New Space Rocket Family 26
▶ Project Scout designed to provide low-cost means of orbiting payloads; USAF has similar proposal.

Supersonic Transport May Aim at Mach 3 38
▶ Aircraft price estimated at $20 million; development phase probably will skip Mach 2, IAS members told.

Sikorsky Broadens Its VTOL Research 66
▶ Helicopter manufacturer's new VTOL research group reflects interest in all areas of direct-lift aircraft.

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EDITORIAL

The Familiar Mixture 21

COVER: Two-hundred-ton antenna at Goldstone tracking station, Camp Irwin, Calif., is expected to be able to track space probes to a range of 40 million miles by 1960 and to four billion miles by 1962 (AW Dec. 15, p. 28). The 85-ft. radio telescope is mounted 110 ft. above ground. The station was built, and is operated by, Jet Propulsion Laboratory.

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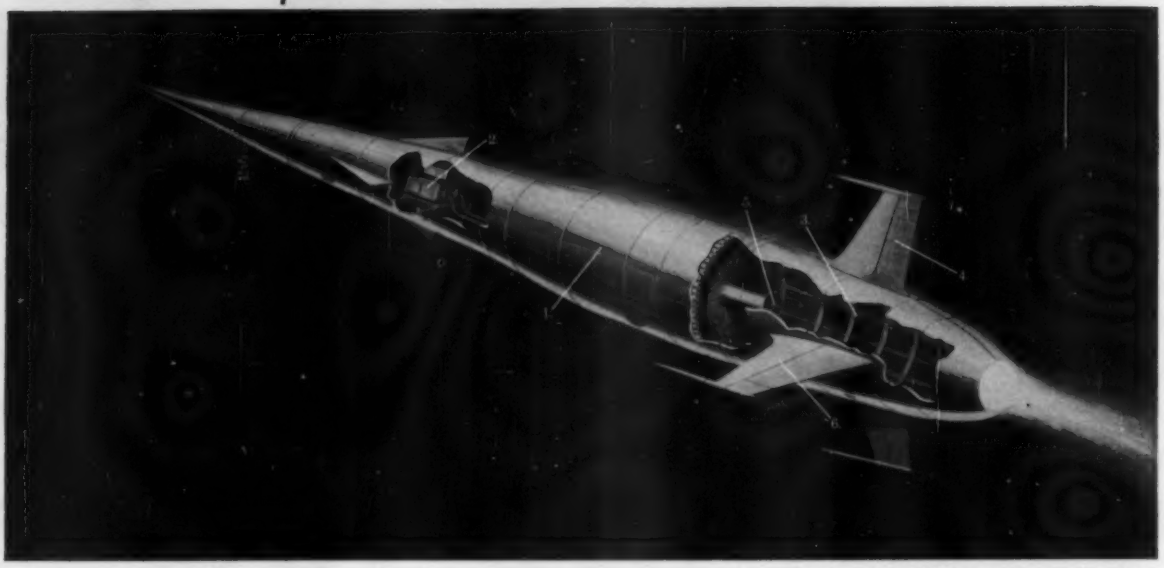

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Most engineers are aware of the advantages available to them when they combine magnesium's light weight with its good mechanical properties at elevated temperatures up to 800°F. There are, however, other advantages such as thermal properties that are less well known. They, too, can be of real value to missile designers. In many cases they will open new areas in design previously considered closed to magnesium.

Let's consider one of these, magnesium's high specific heat and its relationship to missiles. This can mean lower temperatures for given flight conditions. As a result magnesium can be used under very severe flight conditions for short time applications. (See Fig. 2.) This permits the use of magnesium in high speed missiles which are exposed to heat generating atmosphere for only a matter of a few seconds. With magnesium acting as a heat sink it can result in reducing environmental temperature for electronic instruments.

Magnesium offers other thermal properties that are of value in aircraft and missile design. For example, the thermal diffusivity of magnesium-thorium alloys $\left\{\frac{\text{Thermal conductivity}}{\text{Specific heat x density}}\right\}$ is high and remains fairly constant over a large temperature spread. Between 68° and 900°F. the thermal diffusivity of these alloys is in the range of 0.57 and 0.75 cm.²/sec. (2.2 and 2.9 ft.²/hr.)

For more complete data send for Bulletin 141-187 "Magnesium Alloys for Elevated Temperature Use." Contact your nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department 1300X2-2.

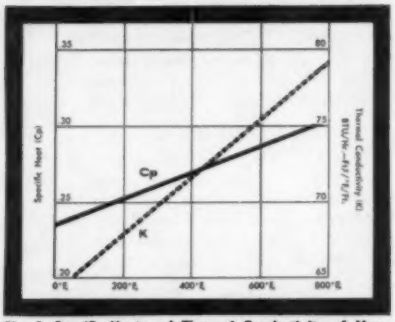

Fig. 1. Specific Heat and Thermal Conductivity of Magnesium-Thorium alloys.

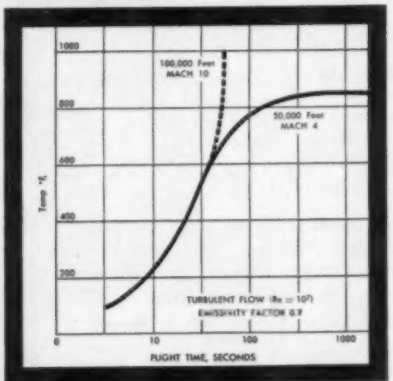

Fig. 2. Effect of Structure Temperature and Flight Time on Mg-Th Sheet Alloys at Mach 4 and 50,000 Feet and Mach 10 and 100,000 Feet.

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EDITORIAL

The Familiar Mixture

The Fiscal 1960 defense budget is the familiar mixture found in similar budgets of the past four years. It is not adequate to meet the current and future defense requirements of this nation nor adequate to regain or maintain a clear cut margin of significant superiority in the technological race with the Soviet Union. Neither is it a drastic attempt to reduce our present defense posture by affecting large and critical economies through forced reductions or weapons production curtailment.

As usual, there is a somewhat pathetic attempt to substitute bold ringing phrases in the budget message for the vital dollars and priorities in the budget itself. For example, the budget cheerfully notes that more B-58 supersonic bombers will be purchased in Fiscal 1960 than in 1959. This, of course, is true, but the actual figure is an increase of only four from the 36 B-58s programmed for Fiscal 1959 to 40 for the next fiscal year. This stretchout of the B-58 production program is typical of how fiscal policies can vitiate technical capability. By the time the B-58 begins to reach a true operational capability with Strategic Air Command under a less than four-a-month production program, it will be all too easy and perhaps logical to wash it out completely on the grounds of obsolescence. This has been the history of several promising weapon systems developed in good technical time but stretched to death by budget maneuvers.

Cancellation of the Regulus II Navy submarine-based supersonic missile is another good example of this false economy that looks neat and tidy on a balance sheet but actually cuts a vital portion of our atomic delivery capability. The Regulus II would have provided the Navy with an operational submarine-based atomic delivery capability in the immediate future. It has been canceled presumably because Polaris is just around the corner. Polaris is coming along well, but it is far from just around the corner. In the intervening years, the U. S. loses a type of operational capability for its strategic deterrent force that offers mobility and dispersal.

Another interesting point to note in passing is the way facts that are subject to vigorous official denials in previous years inevitably leak out in the budgets of following years. In early 1957 we wrote that the Fiscal 1958 Air Force budget was a fraud because it promised to support a 128-wing structure when actually it was capable of handling only 120 wings at the time and would force a reduction below 110 wings within two years. This was vehemently denied by responsible officials including Mr. Donald Quarles, then Secretary of the Air Force and now Deputy Secretary of Defense. Tables published with the Fiscal 1960 budget show the Air Force reduced to 102 wings.

The twisting of the fact that the first Atlas ICBMs will be delivered to Strategic Air Command before July into an impression that this nation will have an operational ICBM capability of any significance during this year is another example of how official weasel wording and innuendo combine to lure the American public into a false sense of complacency. The total Atlas production program scheduled for Strategic Air Command is ridiculously small in terms of real deterrent force. The Titan ICBM is at least a year behind the Atlas in development and has yet to make its first successful test flight.

The decision to abandon all manned interceptors for air defense purposes contained in the Fiscal 1960 budget is another policy that will rise to haunt its progenitors if a test of military strength comes during the next five years. Defensive missile capability, including both the Army Nike Hercules and USAF Bomarc, is certainly improving over ranges under 300 mi. But both for reliability standards, which missiles are far from achieving, and the ranges at which an enemy attack must begin to be whittled away, only manned interceptors will be able to do the job. To completely abandon this capability for the future is a grave error.

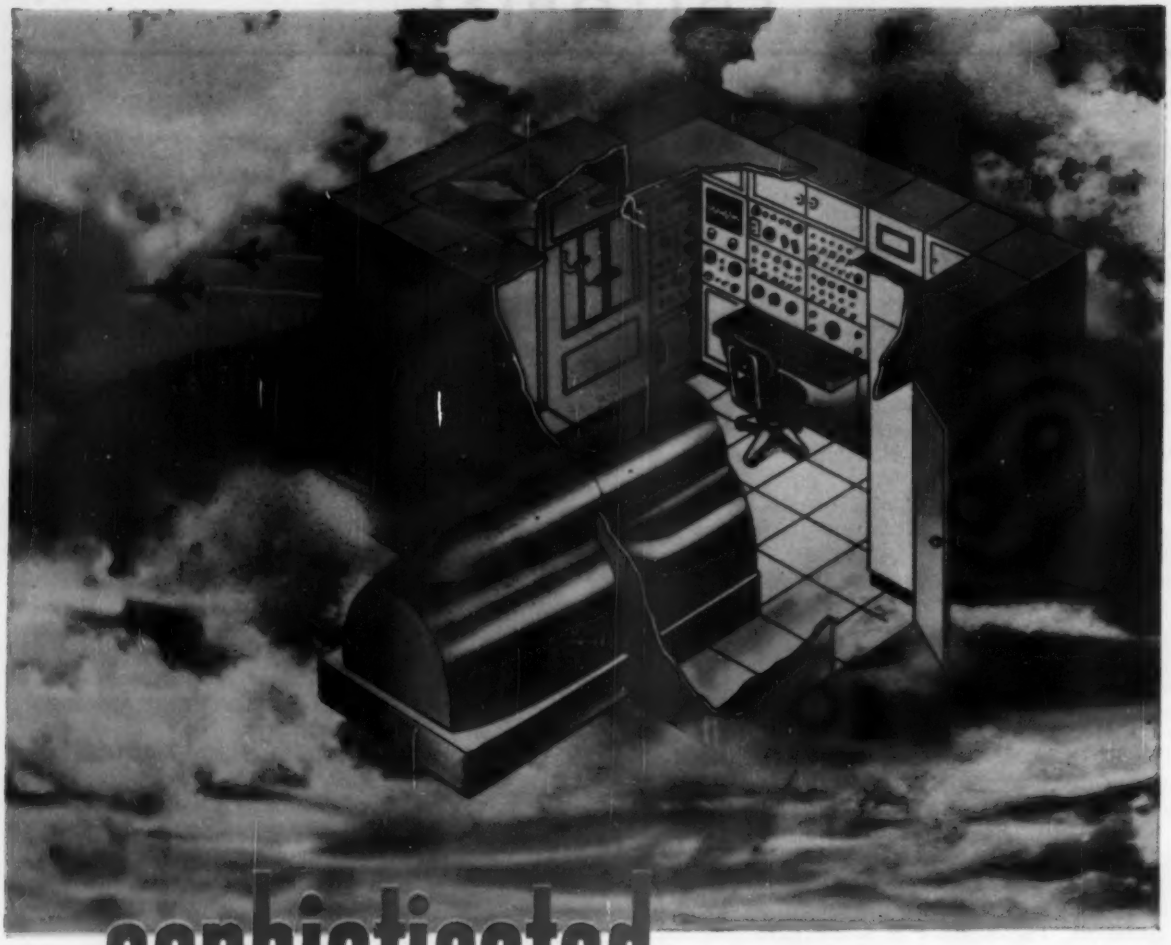
The budget also tells us that procurement of the Thor and Jupiter IRBM will cease in 1960, leaving us with an operational capacity of five Thor squadrons and three Jupiter squadrons deployed in England, Italy, Alaska and possibly Greece. This capability is sufficient to make the areas involved prime enemy targets but not sufficient to add a significant force to our over-all strategic deterrent. In fact, the land-based IRBM program could well become a prime example of how vast sums of money can be hastily spent without achieving any significant new military capability.

Another bookkeeping trick designed to cloak the true state of affairs is the new budget account for research and development which lumps all development and testing facility and operational money in with the research and development funds to make a grandiose total of $3 billion. Probably less than 10% of this total is really being earmarked for basic research and state-of-the-art advances not tied to specific weapon system development. The research and development effort has actually been losing ground despite what looks like an increasing budget because the real research funds have remained almost constant in the face of a tremendously increasing requirement while the budget picture has been rosied by these accounting tricks.

Major bright spot in the budget is the emphasis finally being placed on space exploration with a total of $800 million allocated for this purpose for the National Aeronautics and Space Administration and the Defense Department's Advanced Research Projects Agency. Why this space exploration effort continues to be split by an artificial military-civil distinction is a question not yet satisfactorily explained. There is already the ferment of a bitter congressional debate over the Fiscal 1960 defense budget. We doubt if anybody will seriously make much of a case for it being really adequate to meet the military problems of the future. Its defenders will probably rely on the twin fantasies that we really face no threat from the Soviet Union because their scientific, military and economic advances are pure fiction and that we really "can't afford" what is necessary to ensure our survival as a nation.

But mere debate over the size of the Fiscal 1960 defense budget will not solve the basic problem facing this nation. Nothing less than an aroused and dynamic official leadership willing to grasp the challenge of the future rather than simply preserve the aura of the past is necessary to alter our present course of apathetic drift into decline.

—Robert Hotz



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WHO'S WHERE

In the Front Office

Dr. Bernhard H. Goethert, a director, ARO, Inc., Tullahoma, Tenn. Dr. Goethert is chief of the engine test facility at Arnold Engineering Development Center.

Thomas V. Jones, senior vice president of Northrop Aircraft, Inc., Beverly Hills, Calif., elected a director; the board's authorized membership has been increased from 11 to 12.

Edmund Converse, board chairman, Bonanza Air Lines, Inc. Mr. Converse continues as president. Also: **Chester M. Glass, Jr.,** a director.

Frank U. Hayes, president and general manager, Sperry Products, Inc., Danbury, Conn.

Lewis B. Maytag, Jr. has succeeded C. A. Myhre, resigned, as president of Frontier Airlines, Inc. Mr. Maytag continues as board chairman.

Dr. Edward B. Doll and **Dr. George E. Mueller,** vice presidents, Space Technology Laboratories, Inc., Los Angeles, Calif. Dr. Doll continues as program director for the USAF's Atlas; Dr. Mueller continues as director of STL's Electronics Laboratory.

Eben H. Jones, vice president and general counsel, Thompson Ramo Wooldridge, Inc., Cleveland, Ohio. **John Harlan Kerr** succeeds Mr. Jones as secretary.

Richard W. Lee, vice president-engineering and research, and **William P. Hilliard,** vice president-administration and manufacturing, General Precision Laboratory, Inc., Pleasantville, N. Y.

Dr. Lloyd T. DeVore will be corporate vice president and director of a new Hoffman Electronics Corp. division, to be known as the Hoffman Science Center, Santa Barbara, Calif.

Walter G. Bain, vice president, Washington, D. C., office, Defense Electronic Products, Radio Corporation of America.

James N. Lew, vice president of Beech Aircraft Corp., Wichita, Kan., has been named to head all military activities. Also: **Mason Shehan,** manager, Beech's Washington, D. C., office.

Honors and Elections

Henri J. Lesieur, general manager of the North, Central American and Caribbean Division of Air France, has been awarded the French Medal of Honor of Aeronautics in recognition of outstanding achievement in the field of commercial aviation on the North American continent.

First annual Louis W. Hill Space Transportation Award has been made posthumously to **Dr. Robert H. Goddard,** American rocket pioneer, for "significant contributions indicative of American enterprise and ingenuity in the art and science of space flight."

Dr. Hubertus Strughold, Adviser for Research and Professor of Space Medicine at the Air Force School of Aviation Medicine, has been named the 1958 winner of the Dr. John J. Jeffries Award for "his outstanding contributions in space and aviation medicine research."

(*Continued on page 95*)

INDUSTRY OBSERVER

► Thompson Ramo Wooldridge's Tapco activity in Cleveland, Ohio, and Pratt & Whitney Division of United Aircraft Corp. have study contracts for development of a movable nozzle thrust vector control system for Air Force's Minuteman solid-propellant ICBM. At least five full duration firings will be required for preliminary nozzle proving.

► **Solid fuel gas source for the Minuteman's auxiliary power supply is being developed under USAF contract by Standard Oil Co. of Indiana's Research and Development Laboratory.**

► Anti-ballistic missile defense feasibility study contracts will be awarded by Air Force to seven companies, including Boeing, Convair, Lockheed, General Electric, General Mills Mechanical Division and Radio Corp. of America. If results are encouraging, Air Force may abandon plans to develop new airborne early warning and control aircraft and use latter funds for new anti-ICBM development program. Air Force last week notified bidders for AEW&C airplane program that decision on choice of contractor would be deferred at least sixty days.

► **Recent postponement of the planned initial launch of the Lockheed-managed Project Discoverer from Vandenberg AFB, Calif., was caused by an explosion in the second stage which destroyed the inter-stage structure plus some guidance equipment in the top of the Douglas Thor booster. Fortunately, Thor had not been fueled, but red fuming nitric acid oxidant for the second stage Bell Hustler engine flowed into it and caused damage farther aft in the booster. Vehicle has been returned to Douglas for repair.**

► General Electric J93 engine is scheduled to be selected for North American Aviation's Mach 3 B-70 bomber and F-108 interceptor although the formal decision between it and Pratt & Whitney's J58 won't be announced until approximately Feb. 15. J93 was designed specifically for these aircraft; thus far, is well within its development timetable.

► **Planned budget for Navy's Eagle long-range air-to-air missile system includes about $7 million for the first year, $8 million for the second, $10 million for the third, $14 million for the fourth and about $60 million for the fifth, which would include production. Prime contractor for the system is Bendix Systems Division, Ann Arbor, Mich. Bendix Pacific Division is developing guidance and control. Grumman will build the missile airframe, which probably will be funded separately, and Aerojet-General is favored for the engine, which also will be funded separately. Interim guidance radar in the aircraft is scheduled to be North American Autonetics Division's ATQ75, the same as that used on the McDonnell F4H. Final radar, however, is scheduled to be a Westinghouse development.**

► Four different types of airborne takeoff monitors are being evaluated by Wright Air Development Center's Flight Control Laboratory which hopes to select best design for procurement by this summer. Companies whose takeoff monitors are under evaluation include Avien, Hamilton Standard Division of United Aircraft, Minneapolis-Honeywell and Sperry Gyroscope (AW June 23, 1958, p. 65; July 28, p. 77.)

► **General Precision Laboratory has scored a breakthrough in inertial guidance components with successful operation of a nuclear-spin gyroscope which makes use of atom's spinning electrons instead of familiar rotating mass. Program is one of several projects sponsored by Wright Air Development Center's Weapons Guidance Laboratory in an effort to achieve a major advance in accuracy and reliability of inertial guidance systems (AW May 26, 1958, p. 23.).**

► Designation of Air Force's Global Communications Supporting System has been changed from 456-L to 480-L to avoid possible confusion with Strategic Air Command Control System, 465-L.

Barden Precision SFR1-5 miniature bearings as used in a computer gear train.

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Precision-built computer gear trains must have uniformly low torque and minimum backlash; mounting surfaces for the bearings should be simple to manufacture.

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Washington Roundup

Nuclear Plane Snub

Navy proposal to convert the British Princess seaplane into a subsonic nuclear powered airplane within four years has again been turned down by the Defense Department, a Joint Congressional Committee on Atomic Energy was told last week. Proponents of the plan contend that it would provide the U.S. with its first nuclear plane since it is estimated the Air Force program, if continued at its current rate, will take at least five years to complete. Rep. Melvin Price (D.-Ill.), chairman of the Research and Development Subcommittee, reported that the proposal had been turned down after hearing closed-door testimony by Navy Secretary Thomas Gates, Jr. Price said he would gladly have supported that program—or any program—that would get a nuclear-powered aircraft in the air.

Earlier, Price quoted Air Force Secretary James H. Douglas as testifying that a nuclear plane would be "desirable." Price said Air Force testimony in general indicated that there is a requirement for a flying test-bed nuclear aircraft. Administration officials, however, contend that no requirement has been established for such a test-bed.

Space Hearings

In a related area, the House Committee on Science and Astronautics will begin hearings today to determine the progress being made in the national space program. Rep. Overton Brooks (D.-La.), committee chairman, says the hearings will be primarily a review of programs now under way or planned. Brooks, however, has asked for authorization to create an investigating subcommittee with a $300,000 budget to undertake an extensive probe of all phases of science and technology.

Department of Science

On the Senate side, Sen. Hubert Humphrey (D.-Minn.) is trying to gain congressional support for his legislation creating a Department of Science and Technology, but, thus far, the response has not been enthusiastic. Similar legislation introduced last year failed to reach even the hearing stage. However, the Senate Government Operations Committee, with jurisdiction over the measure, has promised hearings this session on "essential steps that should be taken now to properly reorganize and coordinate the various science programs of the federal government. . . ."

Airline Strikes

Labor Secretary James P. Mitchell has thrown cold water on legislation sponsored by Sen. Spessard Holland (D.-Fla.) that would ban airline strikes and provide for compulsory arbitration of disputes. The experience of other countries, Mitchell said, "has been that they could no more drop government into the arbitration of a few private matters without government domination of many other private matters than they could drop a stone in a pond without causing ripples."

What inevitably follows from compulsory arbitration, Mitchell continued, "is that government soon finds itself setting wage scales, fixing the conditions of work, determining hours, hearing grievances, and throwing its dictatorial weight around in other private matters."

Although compulsion was introduced in other countries to end strikes, Mitchell declared, "it did not end strikes. What you find is a constant rash of hit-and-run strikes, day-long stoppages, slowdowns, etc. These are labor's way of protesting what they think unfair decisions from government. By the time they are dragged into court for striking, they are not on strike. Until the next day, when it starts all over again."

Patterson Proposal

Creation of a Department of Transportation with presidential cabinet status also is being proposed. W. A. Patterson, president of United Air Lines, wants a cabinet post created that would serve as a single regulatory authority for air, rail, bus and water transportation "with a sole interest in the welfare of the nation and its carriers." He said that when such an organization materializes, "we may realize the full potential of transportation service to the American public." He noted that the cabinet post may not appear for many years and added, "it certainly cannot come through consolidation of existing regulatory authorities."

New Cargo Emphasis

Watch for a new emphasis on cargo and air freight sales by scheduled airlines during the next few years as a result of an increased cargo lift capacity that will be brought about through the introduction of turbine-powered transports. During the first full year of operations with its Boeing 707-120 and Lockheed Electra fleet, American Airlines will increase its cargo capacity between 20 and 25%. By 1962, when the airline expects to complete conversion to turbojets and turboprops, cargo lift will be double the 100 million ton miles of airfreight handled during 1958.

Boeing 707-120s operated by American have a cargo compartment with a capacity of 920 cu. ft., sufficient space to hold 10,000 lb. of freight and mail on an average American flight.

New Luggage Proposal

Scheduled airlines last week launched a major campaign to break airport terminal bottlenecks created by present check-in and baggage handling procedures. In a letter sent to the Federal Aviation Agency, John Lundmark, assistant vice president of the Air Traffic Conference, proposed a change in Civil Air Regulations that would permit the use of an average weight for each piece of checked or carry-on luggage. This, according to Lundmark, would eliminate present time-consuming and costly procedures involving the recording of weights and number of pieces of baggage on each baggage check and the preparation and completion of baggage manifests.

Thus, the Air Traffic Conference proposes to use an average weight of 23.5 lb. for each piece of checked baggage and an average weight of 12 lb. for each piece of carry-on luggage. The averages were reached from extensive surveys conducted by seven trunkline and local service carriers. All baggage would still be weighed for excess baggage purposes but present clerical work would be eliminated to help accelerate check-in procedures at airport terminals. According to the ATC study, savings for one major airline with the revised methods would amount to $156,000 annually. **—Washington staff**

Space Technology

NASA Plans New Space Rocket Family

Project Scout designed to provide low-cost means of orbiting payloads; USAF has similar proposal.

By J. S. Butz, Jr.

Washington—National Aeronautics and Space Administration is awarding initial contracts for Project Scout under which a new family of high performance solid-fuel rocket engines will be developed to provide a low cost means of sending instrumented payloads ranging up to a few hundred pounds into low orbits around the earth or to an altitude of approximately 5,000 mi.

This family of rockets will be clustered and grouped together to provide an off-the-shelf capacity for constructing a wide variety of multistage vehicles needed to send instrumentation packages into space at much lower cost than can be achieved with any of the modified military rocket vehicles now available.

The building-block quality of the Project Scout rockets probably indicates that development contracting will involve more firms than is usual for a single solid-fuel rocket system.

Project HETS

Air Force also has a modular rocket program designated Project HETS (High Environmental Test System) which has much the same purpose as Project Scout but was not funded last year.

Apparently no contracts for this program have been let.

Project HETS is an outgrowth of Project BMTS (Ballistic Missile Test System), a broad program designed first to give the Air Force a low cost means of testing ballistic missile equipment at low altitude and, eventually, to send payloads to the moon and beyond. The BMTS program (AW June 16, 1958, p. 175) included liquid as well as solid fuel rockets.

Magnitude of the savings in space exploration costs that are anticipated through Project Scout was explained recently by Dr. Homer Joe Stewart, director of NASA's Office of Program Planning and Evaluation. Dr. Stewart said that it should be possible to reduce the cost of placing one pound of payload into orbit from the lowest current figure of about $10,000 to approximately $300. This would be accomplished simply by using present technology to design rocket systems specifically for space purposes rather than employing the military rockets in interim use today.

Lift Capacity

In terms of lifting capacity, Dr. Stewart said that this meant that today's best ratio of 1,000 lb. of vehicle weight required to place one pound into orbit could be lowered comparatively easily to about 40 to one. He also believes that a figure of 25 to one is consistent with the current state of the art.

Dr. Stewart said that the present practice of constructing badly matched, multistaged vehicles from various unrelated rocket systems has been inefficient and expensive even though it has been unavoidable in getting the space program under way.

The ratio of 40 lb. of vehicle weight required to put one pound into orbit quoted by Dr. Stewart applies to liquid fuel rockets. The value would be slightly higher for the most modern solid fuel systems.

Total cost of using the solids would be lower than the liquid fuels in many cases, however, because savings often can be achieved through reduced handling and personnel requirements. Technology available in the Lockheed-Navy Polaris missile program will aid the designers of the Scout series of engines in achieving this desired performance.

Scout Instrumentation

Instruments sent aloft by Project Scout vehicles will be used primarily to "sound" space around the earth and, eventually, to provide a quantitative understanding of the phenomena occurring in this region.

Another use will be to subject new space vehicle equipment to environmental tests.

Use of the Project Scout "sounding vehicles" will become fairly common because of the large amount of data needed to precisely map the environment near the earth. Payload capacity of the Scout vehicles fits in with the requirements of the scientists who are trying to understand this space environment. For instance, one need is to send a mass spectrometer weighing about 200 lb. into the radiation belts around the earth. This instrument will allow them to determine what particles are present in the belts, their energies, etc.

New Liquid Units Planned

NASA planning also includes the immediate development of liquid fuel rocket systems that will meet the efficiencies possible with present knowledge. These engines will range in power between those planned for Project Scout and the one to 1.5 million lb. thrust engine that the Rocketdyne Division of North American Aviation has under development for NASA.

A definite timetable by which Project Scout and other improved space vehicle systems will be developed has been withheld by NASA and, if the agency's present policy prevails, such a timetable will not be announced. NASA officials say they do not want to promise accomplishments in space on specific dates that they are not reasonably sure they can meet. Also, they do not believe they can predict technical developments years in advance. Therefore, they are declining to state exactly when they believe the one million pound thrust engine will be ready to use, when it will be possible to put a man into space or accomplish the other space flights that are scheduled to follow.

Canadair CL-41 Engine

Canadair Ltd. will use Pratt & Whitney JT12 turbojet engines on loan in initial testing of its CL-41 jet trainer though no commitment has been made for the use of any engine.

Fairchild J83s previously were ordered for initial use in the aircraft but the U. S. Air Force canceled the project. Canadair also has discussed availability of the General Electric J85 engine. Future of the Canadair trainer will depend greatly on the final decision Canada makes on manned versus unmanned interceptors.

Swallow Research

London—British Ministry of Supply says an agreement is expected to be reached soon for an Anglo-American joint research program on the Swallow variable-geometry principle.

In a written answer to a Parliamentary question, Supply Minister Aubrey Jones said that negotiations between the Ministry, Vickers, and U. S. authorities are nearing conclusion. He said the program would get some British government finance.

Jones said it was too early to predict to what aircraft requirement the principle might be applied.

Four JT12 Engines to Power Lockheed Jetstar

Four turbojet engine configuration is shown on this mockup of the Lockheed Jetstar transport, which will be powered by Pratt & Whitney JT12 engines (AW Jan. 26, p. 35). Total weight, including 10 passengers, two crewmen and fuel, will be 30,680 lb. Each engine weighs 430 lb., develops 3,000 lb. thrust. Aircraft will be produced at Marietta, Ga.

Space Technology

Scientists Survey Future Space Potential

By Philip J. Klass

Washington—Communications satellites which relay voice and television over intercontinental distances, weather reconnaissance satellites which greatly improve the accuracy of long-range weather forecasts and military reconnaissance and early warning satellites may prove the most significant products of the next decade's advances in space technology. Perhaps the most spectacular will be the first human landing on the moon and unmanned probes of nearby planets.

House Report

This is the consensus of more than 50 scientists, engineers and top industry executives who express their views of things to come in a 221-page staff report entitled "The Next Ten Years in Space," prepared by the House Select Committee on Astronautics and Space Exploration, and released last week.

By 1969, the U. S. could be ready to plunge beyond the threshold of space with multi-million pound thrust rocket engines capable of putting a 50,000 lb. payload into low-altitude orbit for satellites or being used to build space platforms, and thermonuclear and electrical propulsion suitable for long-ranging interplanetary missions.

By this period the U. S. probably will have made a number of moon probes, including impacting of instrument payloads on the moon. Some of the more optimistic believe that man will have successfully walked on lunar dust by 1969 but the majority believe this must await the next decade.

Dr. Herbert York, Assistant Secretary of Defense for Research and Engineering, says that manned exploration of the moon could take place in 10 years, possibly in as few as seven if very high priority was placed on this goal. Timetable for manned exploration of Mars and/or Venus is "a few years after 1968," according to Dr. York, unless a very high priority program is established.

Recovery of manned satellites and landing in a desired impact area of relatively small size probably will be well in hand by 1968, most observers agree.

Whether the U. S. will find itself in this position in 10 years because of the lack of a well-coordinated and adequately financed program, is a question that disturbs many of those who contributed their views.

For example, George S. Trimble, Jr., vice president-engineering of The Martin Co., says there is little disagreement between scientists over what is technically possible. But in answer to the question of what the U. S. will do during the next decade, Trimble fears that it will be "considerably less than we are technically and economically capable of doing—and somewhat less than the Russians (will do)."

Unmanned satellites providing vital communication, meteorological and navigation services will be the "greatest achievement" of the next decade, in the opinion of Rear Adm. John T. Hayward, Assistant Chief of Naval Operations for Research and Development.

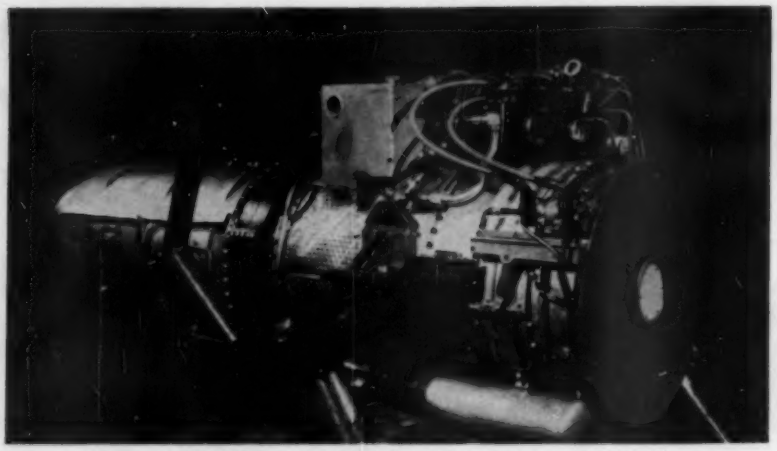
Communication relay satellites for reliable long-range communications and intercontinental television may have one of the greatest effects upon the peoples of the world, in the opinion of British physicist Arthur C. Clarke and Dr. Louis G. Dunn, president of Space Technology Laboratories.

Television Relay Satellite

A television relay satellite capable of bringing television to the uncommitted millions of Asia could be "mightier than the ICBM" in the battle between East and West. Central, low-cost, battery operated television receivers in communities of Asia could be a decisive factor in reaching millions of largely illiterate people, Clarke says.

Even at today's relatively high cost of putting up a satellite relay, the latter is cheaper than equivalent underseas telephone cable per cycle of bandwidth and is comparable to overseas radio which is susceptible to atinospheric outages. Neither cable nor overseas radio can handle television. Dunn predicts that this type satellite will have more direct effect on the man in the street than any other development in space technology in the next decade.

Meteorological satellites capable of



General Electric J85 Tested on Missile

General Electric J85-3 lightweight turbojet engine, now being flight tested in McDonnell GAM-72 decoy missile, is shown at company's Small Aircraft Engine Department at Lynn, Mass. Engine is in 2,000 lb. thrust class, also is used as powerplant on North American T-39 Sabreliner jet transport and Northrop T-38 Talon supersonic jet trainer.

providing weather forecasters with vital data on cloud cover and storm formation that is not now available may revolutionize weather forecasting and more than pay their cost. The petroleum industry alone could save $100 million a year in improved inventory planning through reliable long-range weather forecasts, according to E. V. Murphree, president of Esso Research & Engineering Co. When benefits to agriculture and other industries are considered, Murphree estimated that meteorological satellites could save the nation several billion every year.

Dr. York predicts that meteorological satellites "will probably revolutionize the science of meteorology and weather prediction within the next 10 years."

Dr. York and others predict that satellites equipped with radio/radar beacons will become one of the principal navigation aids for ships and aircraft, and perhaps for space craft, on long missions.

In the area of military reconnaissance, Dr. York predicts that satellites equipped to detect ballistic missiles will supplement or even virtually replace ground-based methods and should become one of the keystones of our defense system. Reconnaissance satellites could nullify present advantages of USSR in its ability to make preparations for military action in complete secrecy.

Consensus of propulsion experts is that liquid and solid-propellant chemical powerplants will continue to serve as workhorses of space probes during next decade.

Single engines with thrusts of 1- to 1.5-million lb. should be available within five years, if their development is given "proper support," according to Dan A. Kimball, president of Aerojet-General. Clusters of up to 10 such engines, providing thrusts of 10 to 15 million pounds, should be adequate for space probes of the next decade, Kimball said.

Within next decade, solid-propellant engines capable of lifting gross loads of more than 10 million lb. were predicted by H. W. Ritchey, vice president of Thiokol Chemical Corp. Development of engines capable of producing 10 to 100 million lb. thrust "presents only straightforward problems," Ritchey said. Ritchey also predicted that both solid and liquid propellants with specific impulses at sea level of 325 to 375, and with fuel mass fraction of over 95%, would become available in the next 10 years.

Exotic Propulsion

High-energy liquid propellant engines being developed for upper-stage use should increase vehicle payloads by 50%, according to Eugene Root, vice president and general manager of Lockheed's Missile Systems Division. Root said that recent declassification of Atomic Energy Commission's Project Sherwood fusion-power program would make available new techniques in magnetohydrodynamics for application to plasma propulsion engines.

Nuclear propulsion could be available for operation by 1968 with "strong support," but unexpected problems in the testing and development of flight hardware might delay this date, according to George H. Stoner, general manager of Boeing's Dyna-Soar weapon system program.

Nuclear engines would permit reduction of size, weight of space probe booster systems by a factor of eight to 10, Stoner said.

John A. McCone, chairman of the AEC, in a more conservative statement, said that with "necessary support and guidance," it should be possible to "demonstrate, by full power ground test, a nuclear rocket engine capable of boosting extremely large payloads into space."

Key to the future development of nuclear propulsion and powerplants for use with ion propulsion, lies in the development of high temperature materials suitable for use in reactors, ion guns, plasma guns, cooling loops and radiators, according to Dr. T. C. Merkle of University of California's Radiation Laboratory.

Merkle added, somewhat pessimistically, that nuclear physics cannot be expected to contribute much that is new during the coming decade. Progress will depend upon work in high temperature solid-state physics and chemistry, he said.

Variety of estimates were given for how much the U. S. should spend on its space programs and how much it is likely to spend. Dr. York based his predictions of things to come on a $1 billion annual expenditure plus military space weapon expenditures. Navy Capt. R. C. Truax, of Defense Department's Advanced Research Projects Agency, says U. S. industry has the capacity to carry on space development program of over $2 billion per year, or soon will have. A figure of $1 billion per year for two years, increasing to $4-5 billion annually, exclusive of military expenditures, was used by Dr. Eric Durand of Aeroneutronic Systems Inc.

Accomplishments of the next decade will largely depend upon the "enthusiastic support of a vigorous program by the people and the leaders of this country," Dr. H. Guyford Stever, associate dean of engineering, Massachusetts Institute of Technology, said.

Letter submitting the report to House Committee by the staff that prepared the report, says: "All the plans, programs and projections . . . will count for little unless the U. S. decides to meet this challenge with the mobilization of its private industry as well as public facilities, its resources, manpower, material and money, which the national space effort requires. The indications are the Soviet Union is prepared to make such commitments . . . The U. S. should have the help and partnership of other countries of the free world."

X-15 Flight Date

Los Angeles—North American Aviation X-15 will be taken aloft by a Boeing B-52 for first time in the second week of February. The out-of-atmosphere research aircraft is undergoing component testing.

110 Potential Candidates Chosen For Man in Space Capsule Project

New York—The process of choosing this country's first pioneer in space—the man who will orbit the earth in a space capsule as the climax of the Project Mercury program—has begun with the selection of 110 potential candidates from officers of the Air Force, Navy, and Marine Corps.

Within the next two months, this group is expected to be reduced to a volunteer team of 12 which will begin a training program that will include both simulated and actual flight conditions that will progressively come closer to the conditions of orbital space flight. Final selection of a candidate will be made only when the first manned vehicle is ready to be orbited.

Details of the selection and training program for the Mercury candidates were given to members of the Institute of the Aeronautical Sciences at their Honors Night Dinner last week by Dr. T. Keith Glennan, administrator of the National Aeronautics and Space Administration.

On the basis of criteria established with the assistance of NASA's Aeromedical Committee, headed by Dr. W. Randolph Lovelace, the records of Air Force, Navy, and Marine Corps officers who have been graduated by their service test-pilot schools were screened to select the 110 potential candidates.

The qualifications demanded of this group were:

- **University degree** in the physical sciences or in engineering.
- **Graduate** of a military test pilot school, with a minimum of 1,500 hr. flight time.
- **Younger** than 40 years of age.
- **Less than** 5 ft. 11 in. in height.

Beginning early this month, the astronaut candidates will be called to Washington in groups of about 30 to be given a full briefing on Project Mercury. NASA, Army, Navy, and Air Force biomedical experts will participate in the briefings.

Only after these briefings will the candidates be asked if they will volunteer. From those who say yes, 36 will be chosen for the next phase of the selection process. This smaller group will be given a series of intensive physical and psychological tests, which will include studies of the candidate's ability to cope with the stresses of space flight and with the environmental and other biomedical aspects of flight under confined conditions over a long period of time.

Within two months, NASA expects the selection of the 12 man team for Project Mercury will be complete. This team will then begin training with assignment to the NASA Space Task Group, located at Langley Research Center, under the project direction of R. B. Gilruth. Team will receive additional training at the Johnsville Naval Air Development Center, the Atlantic Missile Range, and the Air Force Wright Air Development Center, as well as at other biomedical centers in the United States.

At Johnsville, the astronauts will undergo training in a centrifuge that very nearly simulates condition in a capsule during takeoff and re-entry. The early testing period will involve balloon flights in Mercury capsules to familiarize them with some of the environmental conditions they must face.

While the team is undergoing this training, technical teams will be testing Project Mercury capsule mockups in increasing degrees of complexity.

Short-range, solid-fuel boosters will be used initially to launch these mockups into suborbital trajectories, followed by longer-range flights using more powerful boosters. Later in the program, animals will be launched in the capsules to better determine the environment the men will experience.

All 12 of the Project Mercury volunteers will receive the same preflight and flight training. Only immediately before the first manned orbital flight will the final selection of the Mercury astronaut be made.

Dr. Abe Silverstein, NASA director of Space Flight Development is responsible for the over-all technical direction of Project Mercury. The program is being conducted with the assistance of the Advanced Research Projects Agency of the Department of Defense.

Keirn Details Nuclear Aircraft Plans

New York—First U.S. manned nuclear-powered aircraft probably will be fitted with engines of approximately the thrust-class of currently flying high-powered conventional gas turbines, such as those in the Boeing B-52 and Convair B-58 jet bombers, Maj. Gen. Donald J. Keirn, Air Force deputy chief of staff, development, nuclear systems, indicated here last week.

He said that USAF has "sequenced events" leading to successful flight of a nuclear-powered manned aircraft, which calls for a high subsonic speed prototype capable of serving dual function of an engine test-bed and a vehicle for studying operational and tactical doctrines.

Gen. Keirn, who previously had pointedly remarked that the U.S. nuclear aircraft program had been subjected to delays due to financial timidity and scientific conservatism (AW Nov. 24, p. 27), last week said that he did not believe that current progress is "dangerously slow," although admitting that he did believe that the Russians will be flying a nuclear-powered aircraft soon. (AVIATION WEEK exclusively reported Dec. 1 that a Soviet nuclear-powered bomber was observed flying in the Moscow region last August.)

Gen. Keirn indicated also that the USAF prototype nuclear-powered airplane probably will be flown initially with non-nuclear engines to check it out aerodynamically, using chemically fueled turbojets.

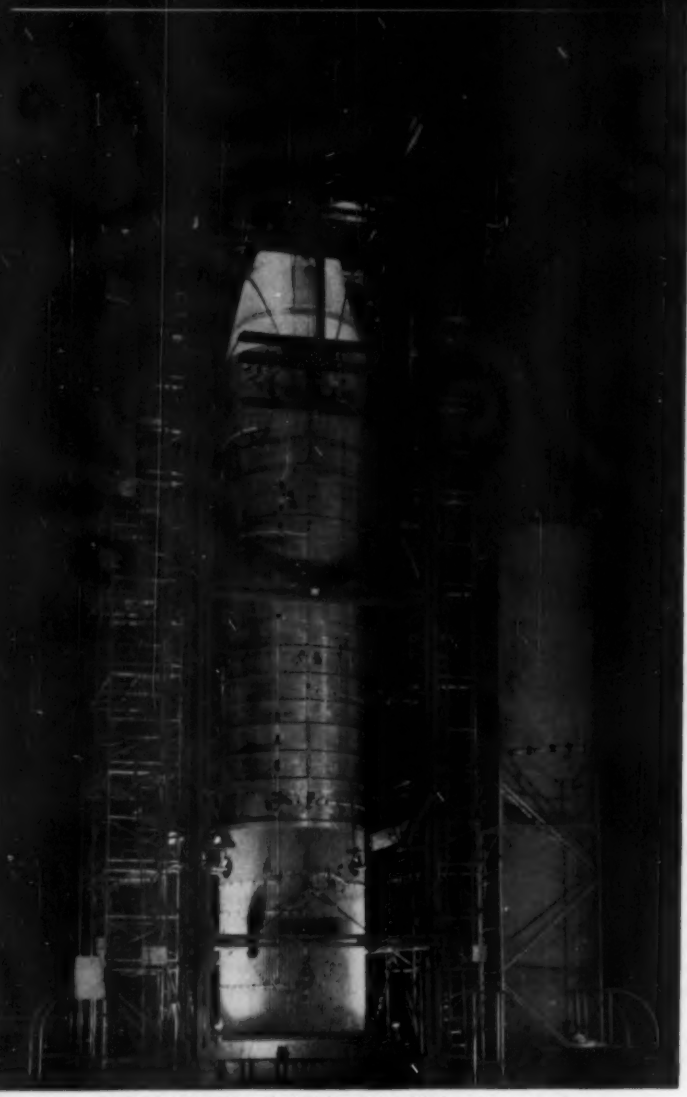
Speaking at a luncheon during the Institute of the Aeronautical Sciences' 27th annual meeting here, Gen. Keirn noted that to date USAF and the Atomic Energy Commission have spent more than three quarters of a billion dollars on the manned nuclear aircraft program.

". . . For this dollar expenditure, I feel that we have sufficiently investigated all of our critical problem areas leading toward development flight testing as the next logical step," the general declared. "I am confident a practical nuclear aircraft can be developed and adapted to military operations in a matter of time only."

Recent progress in aircraft design and integrated shielding techniques have brought over-all system design weights and radiation damage rates down to the point where the U.S. can make use of nuclear power and stay airborne for extended periods, he reported.

Crew radiation dose rates are down to the point where each crew can fly in a nuclear-powered aircraft for 1,000-hr. annually for many years, including missions of well over 100 hr. each, Gen. Keirn added.

He also noted that examination of potential hazards associated with nuclear-powered aircraft have included analyses of accident experience with all U.S. experimental jet aircraft, to study the additional risks that would have been incurred had these planes been nuclear-powered.



WELDING fixtures shown above are used in fabrication of Jupiters. Contract for fabrication was awarded in August, 1957.

JUPITER MISSILE shell (above) is filled with water to measure pressures and bend in loads in simulated flight test to duplicate effect of actual firing. More than 200 channels of strain are recorded. Alignment reference is checked at right.

FABRICATION area for production of Jupiter ballistic missiles at Michigan Ordnance plant of Chrysler Corp. is shown above. Plant now employs about 11,000 persons.

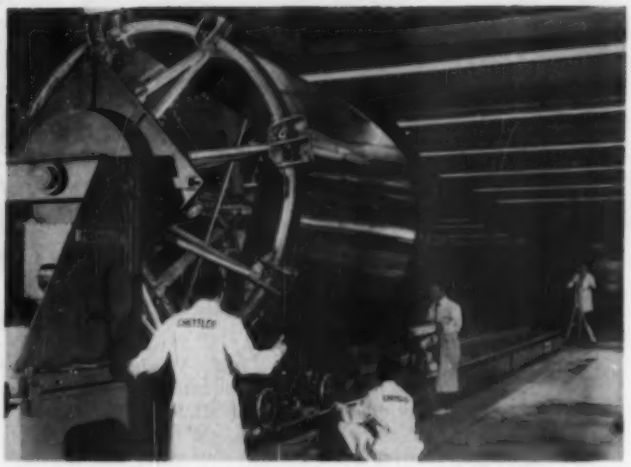
Production of

By Evert Clark

Detroit—Probability that the Army-Chrysler Jupiter intermediate range ballistic missile may be deployed in Air Force squadrons for the next six years or more was suggested last week as Chrysler Corp. opened its Michigan Ordnance Missile Plant to the press for the first time.

USAF now plans to deploy at least three, and probably five or more, Jupiter squadrons in NATO countries. Two are expected to go to Italy, a third to France and another to Turkey or Greece.

First tactical-configuration, production-line model of the Jupiter to be completely assembled by the Chrysler plant was launched from Cape Canaveral, Fla., on Jan. 21, a year and 17



LARGE FIXTURES (above, left) are used in construction of Jupiter missile at Detroit. At right, technicians use optical devices to align Jupiter tank sections. Present plans call for continuation of Jupiter production for at least one more year.

DETROIT plant of Chrysler Corp. produces Jupiter missiles on parallel production lines (above, left). At right, Michigan Ordnance technicians conduct factory tests on Jupiter nose section components. Missile leaves the plant ready for fueling and firing in the field.

Jupiter Programmed for Year or Longer

days after Chrysler was ordered into production of the missile.

The 2.1 million sq. ft. plant, which now employs about 11,000, has been supplying Army Ballistic Missile Agency with major Jupiter components for development and test firings since last spring. ABMA is now phasing out its own limited production of Jupiters.

Both Army and Chrysler declined to estimate what total Jupiter production may be, but Maj. Gen. W. W. Dick, Jr., Army's director of special weapons in the Office of the Chief of Research and Development, said Jupiter's lifetime in the weapons inventory might be as long as "half a dozen or a dozen years."

Unless changing political and strategic requirements eliminate the need for IRBMs, Jupiter's future would seem to be assured until a more advanced weapon replaces it. Gen. Dick pointed out that even the replacement of a weapons system now is a process that takes years rather than months.

Space Potential

In addition to weapons, Jupiter boosters will be used for a number of space missions.

Under present planning, production will continue for at least another year. Plant capacity, according to Chrysler executives, is several times the current production rate.

Jupiter is produced side-by-side with its predecessor, the 200-mi.-range Redstone, in Sterling Township, Mich., 20 mi. northeast of Detroit proper. The plant was built in 1951-52 to produce the Navy-Pratt & Whitney J48 engine, but the project was canceled before Chrysler production began. Brick and mortar costs then was $35 million; tooling and installation costs totaled $100 million.

Chrysler's participation in the missile field—which now totals more than $450 million in engineering, development and production of Redstone, Jupiter and ground support equipment—began in October, 1952, after Army asked the "Big Three" automobile manufacturers if they were interested in producing the Redstone.

At that time, Chrysler sent a contingent of 26 engineers to Huntsville, Ala., for training by Army scientists and engineers. Chrysler contingent there now numbers almost 1,100.

First components and fabrication contract for Redstone came in December,

1953. In June of 1955, Chrysler was given other contracts to supply complete missiles, to fabricate and assemble ground support equipment and to provide engineering services. This was consolidated into a single Redstone contract in December, 1955. Work included original design and development of the stainless steel nose cone.

Entry into intermediate range missile work began when Chrysler did both studies and extensive engineering development work on a fleet ballistic missile system for the Navy.

At that time, the same IRBM was planned for both Navy fleet and Army land use.

First Army contract for engineering and development work on Jupiter came in June, 1956, after Navy had switched to the solid fuel concept for its fleet ballistic missile. Whereas the Redstone work had been largely a production job, Chrysler now played a role in development and engineering of the Jupiter from the beginning.

Contract for fabrication of major Jupiter components was awarded in August, 1957. Orders for production of completed Jupiters, production of some 50 of the 225 ground support items needed by Jupiter and partial responsibility for 100 others and for a logistics support program followed late in 1957 and early in 1958. These orders came after the Defense Department decided to order both Jupiter and the Douglas Thor IRBM for deployment by the Air Force.

Missile Group

Missile production group was given full divisional status within the corporation in January, 1958. Plant is an integrated operation. Ground support equipment components are installed in government-furnished trailers a few feet from the missile production lines.

Chief contribution that Chrysler, as an auto maker, has been able to make in missile production, according to its executives, is a very high degree of reliability based upon tight industrial and manufacturing controls, with the result that the missile leaves the plant ready for fueling and firing in the field.

Checkout facility at the end of the assembly line flight tests each missile electronically. Simulated flight is monitored at simulated downrange telemetry stations, one for Redstone and one for Jupiter.

Thrust, fuel and warhead-control units of the 63-ft., 70-in.-diameter Redstone are interchangeable. The same is true of Jupiter's engines, boosters and warhead-control units. Jupiter is 60 ft. long, 105 in. in diameter; weighs 10,000 lb. empty and 110,000 lb. fueled and ready for firing.

Tolerance for alignment of a Jupiter engine with the skin is .0001 of an inch. Other mating tolerances of .002 and .003 of an inch achieved in production are maintained during shipment.

Examples cited by Chrysler as engineering improvements made in one year on Jupiter were upgrading of the life of a relay from an average of 380,000 cycles to a minimum life of more than one million cycles; an improvement of fueling and loxing valves so that the missile can now be fully loaded with its propellants in two minutes.

Space Technology

Senate Unit to View Space Status

By Ford Eastman

Washington—Senate hearings to evaluate conflicting claims as to where the U.S. stands vis-a-vis the Soviet Union in military and space capabilities, and whether the planned rate of progress is adequate to achieve supremacy in these fields, got under way late last week.

The investigation is being conducted jointly by the Senate Preparedness Subcommittee and the Committee on Aeronautical and Space Sciences, both headed by Sen. Lyndon B. Johnson (D.-Tex.). Johnson, Senate majority leader, said the goal of the committees is to give the American people a forthright answer to the question—"Where does this nation stand in these areas?"

A major part of the controversy developing between congressional leaders and the Administration centers around whether Russia is leading the U.S. in the ballistic missile field, and, if so, by how much. Contributing causes to the confusion include:

• **Vice President Richard Nixon** was quoted in several newspapers as saying the U.S. is ahead of Russia in ballistic missiles and that, while behind in the over-all missile race, it is closing the gap at a fairly rapid pace. Later, "friends" of Nixon were quoted as saying that the Vice President was misquoted (AW Jan. 19, p. 25).

• **Defense Secretary Neil H. McElroy** said at a recent press conference that he does not think the Soviet Union has an intercontinental ballistic missile operational at this time and that there is no positive evidence that it will have initial operational capability on the ICBM earlier than the U.S.

• **Sen. Stuart Symington (D.-Mo.)** former Air Force Secretary, said: "There seems to be a continuing effort on the part of high officials in this Administration to lull the people into a state of complacency not justified by the facts." He said that by the end of 1961 the Russians will have more than four times as many operational ICBMs as the U.S.

• **Soviet Premier Nikita Khrushchev,** in a speech before the 21st Communist Party Congress in Moscow last week, announced that Russia is now producing ICBMs on a production-line basis and that success in launching its recent lunar probe proved that the USSR can launch rockets accurately to any point on earth.

• **Sen. Francis Case (R.-S. D.)** said the U.S. relative position of strength in the missile field is not to be determined by a comparison of progress on one particular missile but should be judged on an over-all basis, including consideration of all types of missiles and the deterrent capabilities of medium and heavy jet bombers.

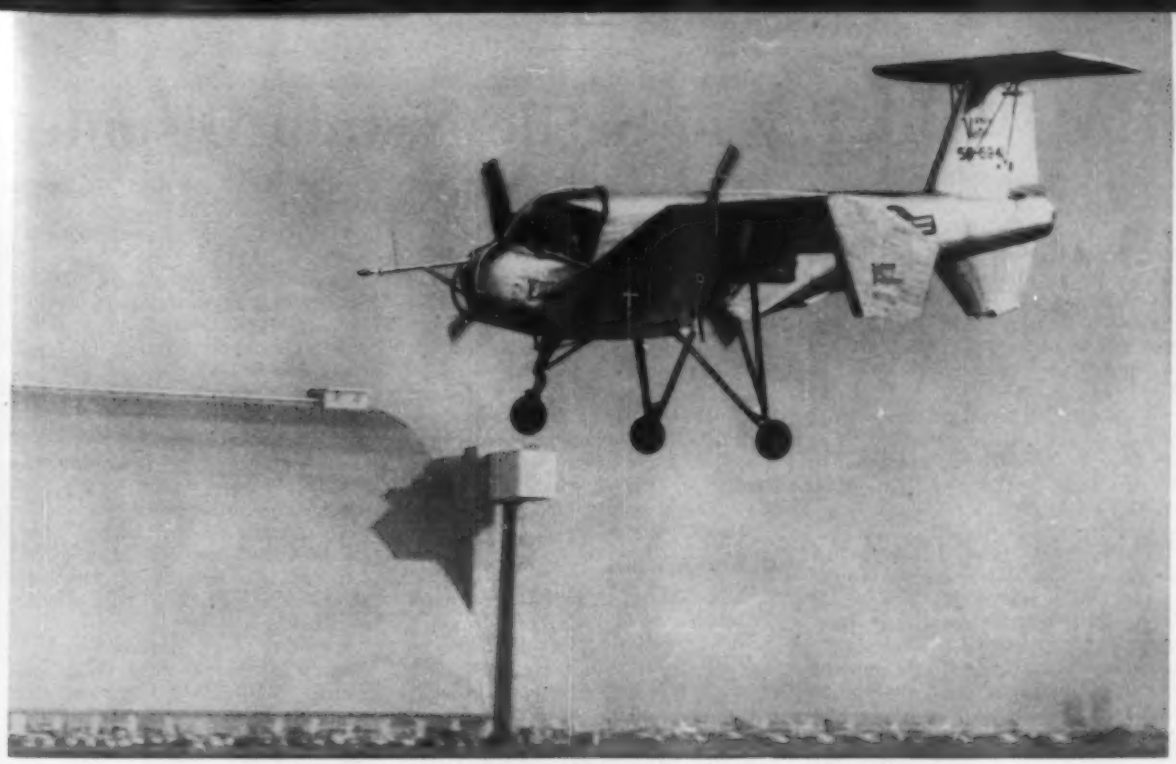
Case generally reflects the Administration attitude toward national defense and space programs in its attempt to keep a balanced budget for Fiscal 1960 and hold defense spending to 1959 levels. Administration officials and Republican members of Congress readily admit that the U.S. is behind Russia in certain individual areas but content that it is leading and on an over-all basis in both defense and space.

Symington took issue with the Administration stand on the importance of the ICBM and also charged that adequate defense for the nation requires more money than estimated in the President's budget for Fiscal 1960. Defense expenditures are estimated at $40.9 billion, or about the same level as during the current fiscal year.

Symington, in alluding to the four-to-one ICBM lead intelligence reports indicate the Soviets will have in 1961, said he believes these figures actually underestimate the Soviet long-range missile advantage now and over the next few years.

Earlier, at a hearing of the House Defense Appropriations Subcommittee, which also is scrutinizing the U. S. defense posture, McElroy said two basic principles were followed in developing the Fiscal 1960 weapons program.

One, is where a program is considered essential. In such cases, the rate of development has been maintained and, where advisable technologically, advanced. The other is where a program, in view of the current state of the art, is of lesser importance or has been overtaken by events. In these cases, the level of effort has been reduced or the project eliminated entirely.



Ryan Vertiplane Flies at Moffett Field

Ryan Vertiplane VTOL research aircraft, which has completed first conventional flight tests (AW Jan. 26, p. 35) at Moffett Field, Calif., is powered by Lycoming T53 gas turbine engine rated at 850 eshp. Engine, mounted in fuselage, turns two three-bladed propellers mounted on pylons. Flaps in full down position deflect propeller slipstream downward to provide vertical lift for takeoff, hovering and landing. Once in the air, flaps are retracted and Vertiplane operates in normal flight attitude. Aircraft is 27 ft. long, 8 ft. high and has wing span of 23 ft.; gross weight is 2,600 lb.

Northrop Weighs N-156F License

New York—Northrop Corp. is discussing plans with three European manufacturers to build the Northrop N-156F lightweight jet fighter overseas, Whitley C. Collins, company president, said here last week.

He told the New York Society of Security Analysts that Northrop is working out production plans with SABCA, of Belgium; Fokker, of the Netherlands, and Fiat, of Italy. Collins said N-156F production also is being considered for Australia, Japan, Canada and Europe.

"Interest in this weapon is so extensive that we estimate its potential world-wide production at well in excess of 4,000 aircraft," Collins declared. Twin-jet aircraft is designed for NATO and SEATO defense force use (AW July 28, p. 55).

N-156F was developed with Northrop funds, but Collins added that U.S. government "has recently supported us and has expressed interest in sponsoring its further development." Aircraft is a fighter version of the Northrop T-38 jet trainer, which will be built for U. S. Air Force by Norair Division. Collins said the training mission will "require several thousand aircraft."

Turning to Northrop's role in space research, Collins noted that Norair Division, as well as the rest of the company, "is determined to keep its feet on the ground, so to speak, while looking at the stars."

Advantages Northrop gains from space research activities, directly in earnings and indirectly in increased technical competence, he continued, "must be commensurate with the investment we make in pursuit of this field of endeavor."

Collins emphasized the company will continue to explore "promising and logical avenues for growth through acquisition or merger," and, in answer to a question, denied that the company is considering a merger with Raytheon Mfg. Co., with which it works "very closely" on the Hawk surface-to-air missile for the U.S. Army.

In addition to merger exploration, the company's future prospects include:

- **Major product programs** still in testing and development phases show "great promise" of moving into volume production in the next year or so.
- **Northrop sales volume** can be expected to expand by "a considerable margin," and coupled with savings through cost control, will result in "quite attractive prospects for earnings."

Collins predicted that Northrop's net sales for the first half of its fiscal year, which closes this month, probably will be slightly below a similar period in 1958, while earnings may be "roughly 20% above the like period a year ago." He explained that sales for the first five months of the current fiscal year totaled about $96 million, against $100 million a year ago. Earnings, after taxes, amounted to $2.6 million, or $1.62 a share. First half earnings last year were $2.1 million, or $1.34 a share.

Asked how much of Northrop's current business is subject to renegotiation, Collins replied: "Unfortunately, 100%." However, a search for non-military products is proceding "aggressively," according to Thomas V. Jones, senior vice president in charge of development planning.

Jones said two areas, in particular, are in the field of guidance for jet transport aircraft, and in air traffic control, adding "we will exploit these when we feel we have a leading position," and can become competitive.

At the moment, about 65% of Northrop's business is in the avionics and missile fields. Order backlog now totals $283 million, of which about one-third is for manned aircraft.

ICAO Will Try to Settle Navaid Dispute

By James A. Fusca

New York—The U.S.-British conflict over which short range navigational aids are to be adopted as standards by the International Civil Aviation Organization for world-wide implementation will be decided at a special ICAO meeting that begins next week in Montreal.

Although all types of short range navigation systems are scheduled to be considered, the only major contenders are the U.S. VOR/DME-T rho-theta system and the British Decca hyperbolic system.

The present standard short range navaid is VOR (VHF omnidirectional range), adopted by ICAO in 1949. In 1951, civil distance measuring equipment was recommended as a supplement to VOR where required, but this DME standard does not conform to the characteristics of the Tacan compatible distance measuring equipment (DME-T) which in combination with VOR makes up the civil portion of the Vortac system now being installed by the U.S.

This country proposed modification of the DME standard to conform with DME-T characteristics at a meeting of ICAO's Sixth Communications Division in the fall of 1957. The move was defeated by the British who proposed that next week's special meeting be called to consider the entire question of short range navigational aids. The intent of the British move was, of course, to force consideration of the Decca system.

Opposing Positions

The U.S. position at Montreal is expected to favor continuation of VOR as an international standard, extension of its use to en route as well as terminal areas, and the substitution of DME-T for the present DME standard.

The British position appears to have shifted between the 1957 ICAO meeting and the present. At that time, they suggested that Decca should be adopted as the primary standard short range navaid, but with VOR preserved as a supplementary aid because of the more than 1,500 present or planned VOR installations around the world.

This position seems to have been modified as the United States has gained apparent support for the Vortac system. The present position is that VOR should be retained as the primary short range aid—but without adoption of either DME or DME-T—and that Decca be adopted as a supplemental aid to be used in areas of very high traffic density.

This means that the British will direct their attack primarily against adoption of DME-T. They will assert that the accuracy of VOR/DME-T (Vortac) is not adequate to provide parallel routes with lateral separation in high density traffic areas, and that the greater accuracy of Decca as a hyperbolic system is required.

The British position also will stress the inherent compatibility and easy transition from a short range to a long range aid if Decca and its long range counterpart Dectra—which is now in trial operation across the North Atlantic—are used together.

U. S. Arguments

United States arguments to counter the claims of limited traffic handling capability of Vortac will include pointing out that many U. S. airports are presently handling more operations per day than London, the busiest Decca-equipped terminal area using only VOR, and that the addition of DME-T will greatly increase traffic capacity by reducing longitudinal aircraft separation now required and by providing many more holding fixes outside the terminal area.

As to easy transition and compatibility, the United States will emphasize the fact that transition from a short range en route navaid to an instrument approach aid favors Vortac because airliners can use VOR receivers for instrument approaches with the ILS system in use around the world, including the United Kingdom.

Both countries have described and demonstrated their systems for representatives of other ICAO member countries as part of their attempts to gain support. The United States held a four day symposium on Vortac last October in Washington and Indianapolis where 30 ICAO countries were represented (AW Oct. 13, p. 43).

The British this week are demonstrating in flights out of New York a Decca installation in a BOAC Comet 2E, operating on the Decca chain in the New York area being used in the Federal Aviation Agency's evaluation of a hyperbolic system for helicopter navigation (AW Sept. 22, p. 32). Similar demonstrations have been held in London and Paris last month, and will be held later this month in Montreal.

Probable Results

Most informed observers believe the United States will win final approval for its VOR/DME-T system, but only after an extremely bitter fight. One factor that tips the balance in U. S. favor is the reported support of the International Air Transport Assn. for VOR/DME-T based on the heavy investment in VOR on the part of international air carriers.

Member states probably will be encouraged to continue the study, development and use of systems such as Decca on an experimental basis but—if DME-T becomes an ICAO standard—all countries will be urged to install VOR/DME-T as the internationally accepted short range navigation aid.

In the documents describing the positions of the various delegations that have been distributed through the ICAO secretariat, the United States and the British have listed their specific arguments pro and con as a basis for the discussions that will take place at the meeting.

According to the United States, its selection of the rho-theta (range and bearing) VOR/DME-T system does not imply that this type of system is the only possible way to provide short distance radionavigation service, nor does it imply that rho-theta systems are to be considered in every way better than hyperbolic systems.

Particular Value

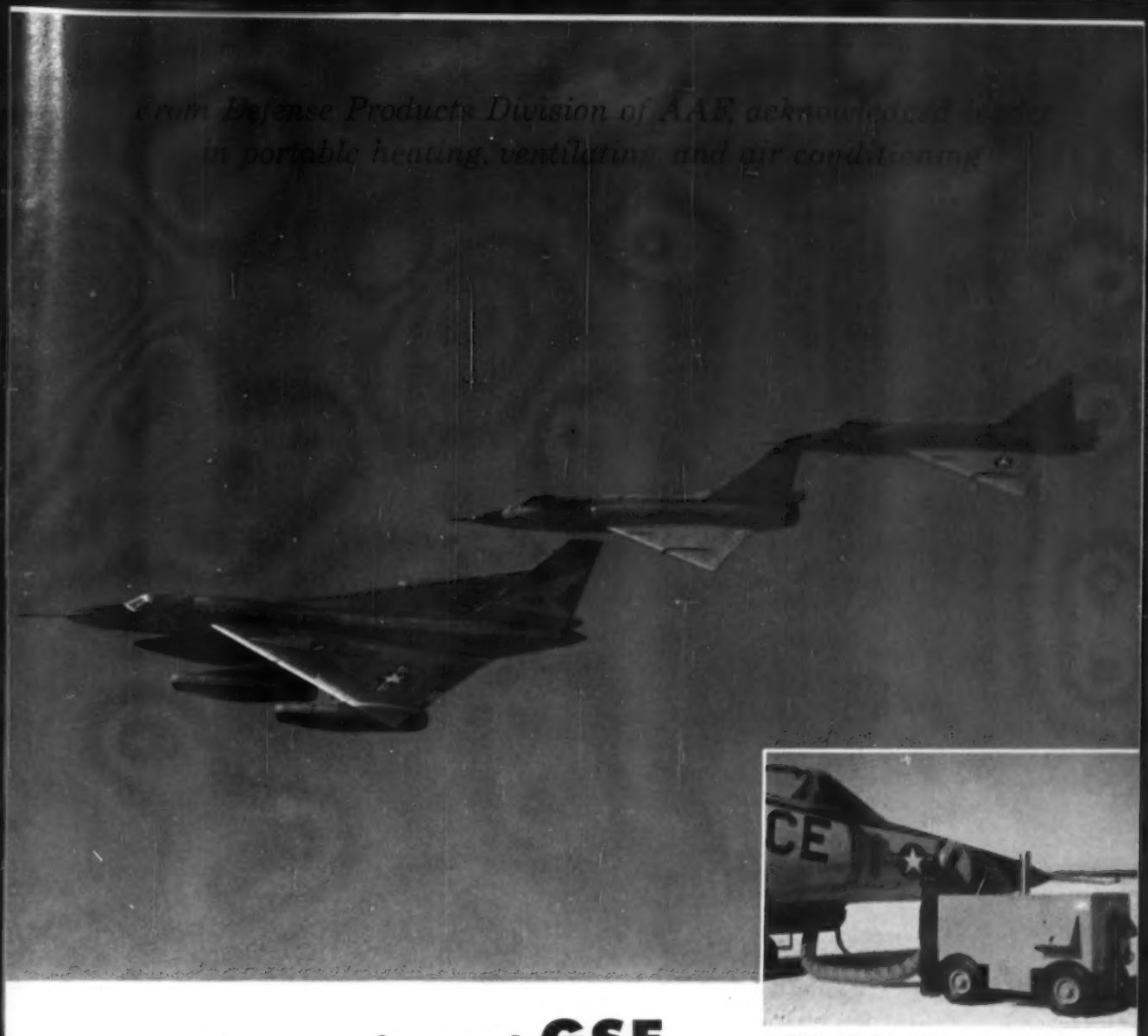
Such systems, the United States says, have value for particular purposes. Considering only their basic technical capabilities, hyperbolic systems may offer greater accuracy than rho-theta systems, and the low frequency characteristics of some may offer coverage to lower altitudes than rho-theta systems.

The United States, however, considers that rho-theta possesses a particular combination of advantages that makes it the most suitable short distance radionavigation system.

Advantages Cited

Among these advantages are:

- **Simplicity** of presentation and use of the system in the aircraft, including the ease and naturalness of interpretation of the information presented.
- **Simple positive** identification.
- **Simplicity** of obtaining a track and a position fix immediately upon selecting the proper channel or after restoration of a lost signal.
- **Ability to use** the basic information of VOR and DME-T without need of computers or complex displays in aircraft to convert basic output information into usable form.
- **Single-site** installation capability.
- **Availability** of a positive over-station fix with simple airborne equipment in addition to the availability of position-fixing ability away from the station.
- **Implementation** of the system and its operation and maintenance are under



HERMAN NELSON portable heating and ventilating unit for the F-102. Each system presented a different problem; each required specially designed equipment. For each, Convair turned to AAF Defense Products Division.

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PIONEERS IN TURBINE POWERED HELICOPTERS

THE *KAMAN* AIRCRAFT CORPORATION • BLOOMFIELD, CONNECTICUT

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Thor-Able Launched

Thor-Able vehicle, with special nose section, carries a version of new Titan intercontinental ballistic missile guidance system at launch at Cape Canaveral, Fla., on 4,400 mi. nose cone recovery test flight.

the control of the state providing the service.

- **Capability,** both on the ground and in the aircraft, of providing theta and rho (VOR and DME-T) on a progressive basis as requirements develop.
- **Protection** of the investment in VOR and the extensive worldwide planning which has been done on the VOR system.
- **Inherent capability** of the simple airborne equipment to perform additional functions, such as ILS localizer and voice communications.
- **Operation** in a static-free part of the radio spectrum.

The British state in contradiction to this that a navigation service based on a rho-theta system currently available will be subject to the following disadvantages and limitations:

- **Rapid fall-off** in fixing accuracy with distance from the station, therefore affording only a short useful range.
- **Lack of continuity** (the need for frequently switching stations en route).
- **Lack of coverage** at low altitudes and overhead the station, resulting in large sections of operationally used airspace being inadequately served.
- **Loss of all** information with loss of signal.
- **Stringent technical** site requirements, coupled with the need for precise location in relation to the air route structure.
- **Consequent** inflexibility of the route structure without expensive relocation of facilities.

The British state that few of the limitations listed for rho-theta systems are inherent in hyperbolic systems when phase techniques are employed, particularly if they are operated in the LF band. Such limitations as hyperbolic systems may have, they say, are less objectionable operationally than those of rho-theta systems.

Chance Vought Gets Navy F8U-2N Order

Dallas—Early next year, Chance Vought will start delivering to the Navy the F8U-2N, a new version of the Crusader which will operate as a "limited" all-weather fighter with a top speed close to Mach 2.

Chance Vought said the F8U-2N was initially authorized from Fiscal 1958 funds and the company expects substantial numbers to be ordered. Development of the new model will have the effect of stretching the production life of the Crusader series, but it doesn't offer any present relief from the layoffs forced by cancellation of the Regulus II and F8U-3 programs.

The F8U-2N is basically an F8U-2 with more power and more advanced radar and autopilot systems. The autopilot is a push-button system developed by Chance Vought somewhat along the lines of the system designed for the ill-fated F8U-3 program, although it is not as complex as the F8U-3 system.

All-weather capability will be provided to a degree by a more advanced Magnavox radar system than the ones on the earlier Crusader models. The F8U-2N also will have the revised interior and exterior lighting systems and improved instrumentation called for by operation at night and in poor weather.

Pratt & Whitney J57-P-20 engine will give the F8U-2N more power than the 17,000 lb. of thrust of the J57-P-16 and afterburner which is in the F8U-2 production model. This added power will put the F8U-2 very close to the Mach 2 mark.

The new Crusader will be equipped to carry Sidewinder air-to-air missiles, plus "newer type missiles now under development." This latter category undoubtedly includes the Sparrow III.

News Digest

Convair Atlas ICBM test firings are scheduled to be made at the rate of four or five per month during the next several months. The better than one firing a week schedule from the Air Force Missile Test Center, Cape Canaveral, Fla., is now in effect with one moderate-range flight of an Atlas C early last week and another scheduled for the latter part of the week. The moderate-range flight reportedly achieved "most" of the test objectives by the Air Force.

Aerolineas Argentinas, Argentine state airline, has bought 10 Fairchild F-27 turboprops and taken an option for 10 more. At current price of $660,000 each, firm order is worth about $6.6 million without spares. Delivery is scheduled to start about October, 1959.

Follow-on contract for more than $80 million has been awarded by U.S. Navy to North American Aviation's Columbus Division for production of additional A3J Vigilante all-weather jet attack planes.

Boron fuels will be produced for U.S. Air Force under $2 million contract awarded to Stauffer-Aerojet Chemical Co.

Federal Aviation Agency has ordered development and production of air traffic control beacon stations from Telecomputing Corporation of Los Angeles, Calif. Project will be handled by Brubaker Electronics, Inc., a wholly-owned subsidiary, on the basis of a $3,069,000 contract. System can control up to 250 planes for 250 mi. radius.

Bristol Siddeley Olympus engine has been selected to power the TSR-2 tactical support and reconnaissance replacement for the RAF Canberra (AW Jan. 12, p. 121). Olympus has reached 24,000 lb. thrust with afterburning.

German Defense Ministry has ordered $14.5 million worth of spare parts for Republic F-84F Thunderstreak jet fighters and RF-84F jet reconnaissance planes now in service with German Air Force. Contract was awarded to Republic Aviation (International) S. A., which will place production of more than 1,500 items with European firms on a subcontract basis.

ARCAS meteorological rocket has been fired to an altitude of 174,000 ft. at White Sands, N. M., test ground. Solid propellant rocket (AW Nov. 3, p. 49) was developed for Office of Naval Research by Atlantic Research Corp.

Supersonic Transport May Aim at Mach 3

Aircraft price estimated at $20 million; development phase probably will skip Mach 2, IAS members told.

By Glenn Garrison

New York—First supersonic transports to see airline service probably will cost about $20 million each, will cruise at Mach 3 or above, and for economic rather than technological reasons, are not likely to be delivered until the early 1970s, in the opinion of manufacturing and airline officials at an Institute of Aeronautical Sciences session here last week.

Engineering officials of Convair, Boeing Airplane Co. and Douglas Aircraft Co. indicated that the Mach 2 phase of airliner development would be skipped in order to offer a more attractive airplane economically and to avoid another re-equipment round.

Mach 2 Program

Convair could initiate a Mach 2 transport program today, with first deliveries in 1965, R. C. Sebold, vice-president-engineering told the IAS members.

This airplane would be a "certain money maker, a good airplane in every sense" but its operational life would last only about five years, when competition from the Mach 3 to 5 transport would appear. Sebold said Convair's studies have included computer evaluation of more than 100,000 supersonic aircraft design parameters and more than 10,000 hr. of wind tunnel testing of the more promising configurations.

One Mach 3 design, Sebold said, promises a 12% advantage over the Convair 880 in direct operating costs. Comparison is based on 100% load factor, 3,000 hr. yearly utilization, 10-yr. depreciation period and each airplane operating at its design range.

Less confidence in the current ability to produce a satisfactory Mach 2 transport was expressed by Douglas in a joint presentation by E. F. Burton, vice president, engineering, transport aircraft systems, and V. V. Holmes, advanced design engineer. To achieve an economically competitive Mach 2 airliner at the level of airframe design expected in 1965-70, new or improved engines would be needed, according to the Douglas officials. These would have to be nonafterburning powerplants capable of continuous operation at high turbine-inlet temperatures, and maximum short-time operation at temperatures near 2,000F.

On the other hand, though a Mach 2 design would require a major engine development program, the airframe structural problems are not particularly severe. Situation with the Mach 3 airplane is just the reverse, in the Douglas view. Such a plane could utilize engines now under development, but would require development of new airframe structural materials and design and production concepts.

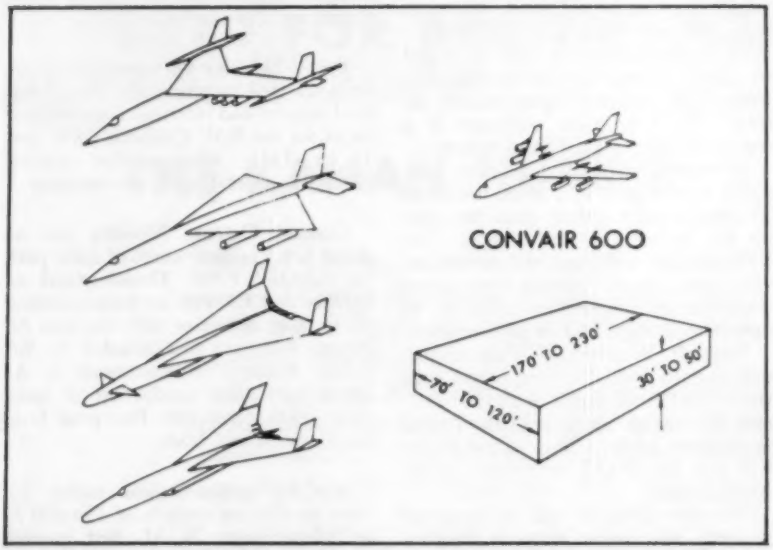
Seat mile production of a Mach 3 transport carrying 160 passengers with average 8 hr. daily utilization and average 2,500 mi. trip length would total 743 million seat miles yearly, about four times that of the large subsonic jets, according to the Douglas engineers. About 80 Mach 3 transports would replace 308 subsonic jets, thus cutting the manufacturer's market and raising the unit cost. If private industry had to absorb the development costs of this limited-market airplane, some $10 million per airplane would be added to the price, Douglas estimates. With production costs running $15-20 million per airplane, the total price tag of $25 to $30 million would be intolerable to an airline.

Travel Market Growth

However, growth of the travel market could create a need for more supersonic transports than the number required to replace their subsonic predecessors, thus spreading the development costs over a larger number of aircraft. Additionally, the Douglas officials noted, there is the possibility of some form of government subsidy of development costs.

General characteristics of the typical Mach 3 transport envisioned by Douglas include six engines, a gross takeoff weight of 500,000-600,000 lb., 3,500 naut. mi. range with capacity payload, cruising speed of 1,725 kt., direct operating costs of $4,000 per hour. Costs also are estimated at $2.60 per nautical mile and 1.3 cents per 200 lb. per nautical mile. Block speed at maximum range is estimated at 1,460 kt. Empty weight of the plane is 200,000-250,000 lb.

Initial cost of supersonic transports and finding the money to buy them are acknowledged by the Douglas officials to be the primary problems for the airlines before purchase of such planes can be seriously considered. The 308 jets bought to date by U.S. domestic carriers for $2 billion, exclusive of parts and ground equipment, will be followed in 1963 or 1964 by fleets of medium range subsonic jets for shorter segments, in the Douglas view. A breathing spell of several years will then be needed before the supersonic next round can be considered. Price tag of this



CONVAIR study designs indicate "typical supersonic transports" for 135 passengers in transcontinental service. Fuselage and tail heights are comparable to subsonic jets. Fuselage length is greater but wingspan is less. Aircraft will not exceed dimensions shown at right.

round will be about the same as that of the initial, large jets, because the per airplane cost of three or four times as much will be offset by a like increase in productivity.

Hence, Douglas feels, it will be 1972-75 before airlines will be able to handle supersonic orders.

Major Problems

The Convair, Boeing and Douglas spokesmen, along with most of the airline and engine manufacturing officials who discussed their presentations, agreed that supersonic design and operational jets would present major problems, including:

• **Decompression exposure.** Because the airplane will be flying at altitudes up to 70,000 ft., it won't be able to descend fast enough to an acceptable altitude in the event of pressurization leak or malfunction. Emergency oxygen equipment will be of no value under the altitude conditions.

• **Sonic boom.** To avoid property damage and public irritation from shock waves, the supersonic transport may have to climb at a speed below Mach 1 at least until 35,000 ft. With descent speed also restricted by this phenomenon, fuel economy and flight times may be drastically affected.

• **Aerodynamic heating.** Aside from its effect on aircraft structure, means must be taken to protect passengers and internal systems from heating of the supersonic transport. Standard glass fiber wall insulation would have to be about a foot thick at speeds approaching Mach 4 to keep walls at 90 deg. and cabin at 75 deg. Other cooling methods therefore must be developed.

• **Air traffic control.** The supersonic jet will be even less tolerant of delays than the subsonic jet in fuel consumption and hourly flight costs, and time for diversions, flight plan changes and the like will be radically cut. It appears also that for an indefinite time the supersonic transport will be mixed in the traffic patterns with subsonic aircraft and handling priorities will be difficult to arrange.

Sonic Booms

The sonic boom problem was described by Sanford B. Kaufman, assistant vice president-engineering for Pan American World Airways, as one which might prove to be one of the most troublesome in supersonic jet operation. The Douglas officials also pointed out that about one-third of total fuel for a typical flight is consumed in climb by the time Mach 1 is reached at 20,000 to 25,000 ft. If sonic boom considerations restrict the climb so that Mach 1 is reached at higher altitudes, fuel consumption problem may become critical. Improvements in engine fuel consumption rates may alleviate this problem, according to Douglas. Taking the problem from another standpoint, Convair's Sebold notes that an 880 flying New York-Los Angeles covers about 83% of the distance at its cruising speed.

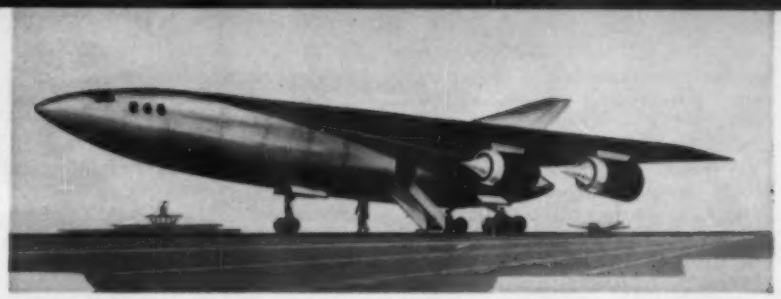
But planes faster than Mach 3 require increasingly more distance for acceleration and deceleration, so that by the time Mach 7.2 is reached the aircraft actually would never cruise at that speed on a coast-to-coast trip. Before it finished acceleration and climb, it would have to begin deceleration and descent, these phases being speed-limited by the boom problem. When transcontinental time has been reduced to an hour, therefore, it will be very difficult to lower it farther.

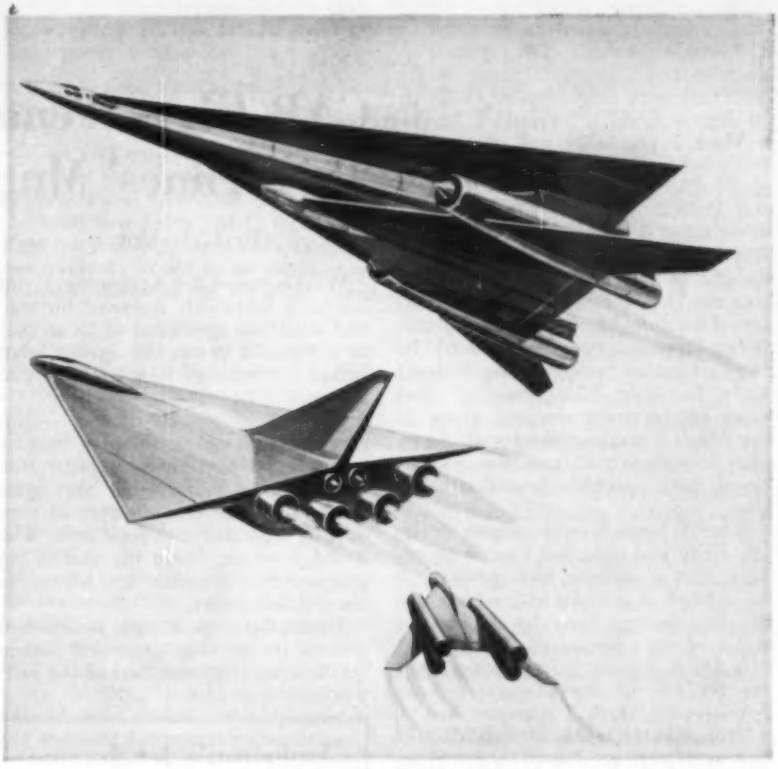
A possible solution to the decompression problem, suggested by M. L. Pennell, chief engineer of Boeing's Transport Division, involves pressurization of the cabin during descent by ram air cooled by water spray. Oxygen service would be provided as in current jets.

Skeptical of Plan

But Kaufman of Pan American was skeptical of this plan and preferred to see the major emphasis in cost and weight built into the structural integrity of the cabin and cockpit.

In connection with cabin design efficiency, a suggested weight-saving





HYPOTHETICAL high Mach number transport carrying 100 passengers (artist's conception, above) could conceivably cruise on ramjet engine power from coast to coast in one hour, according to Marquardt Aircraft Co. Aircraft would weigh about 300,000 lb. and would cruise at Mach 4 at 80,000 ft. Takeoff would be with after-burning turbojet engines; ramjets would take over at 30,000 ft. Ramjet design is similar to Marquardt hypersonic engine drawing shown previously. Below is concept of commercial application design, a combination of ramjet engines for cruise, and turbojets for takeoff and initial acceleration. In a recent ground test, a Marquardt ramjet ran for 50 continuous hours at simulated 73,000 ft. altitude.

idea was elimination of passenger windows entirely, with possibly a closed circuit television system to give passengers a view of the outside.

To handle the cabin cooling problem, Sebold discussed circulation of air or water between inner and outer skins. While this was suggested not as a definitive answer but only as an example of the new approaches required to deal with the problem, Sebold said that other uses might be found for the water used in such a cooling system. These uses might include brake cooling or injection into hot engine sections to prevent crash fires.

Other Points

Among other points touched upon in the papers and discussions of supersonic airline transports:

• **Passengers may have** to get used to much steeper deck angles during climbout. Estimates ranged up to angles of 20 deg. or more.

• **Mach 2 possibility was** retained by two officials, Trans World Airlines vice president-engineering R. W. Rummel and United Air Lines superintendent of technical development Ray D. Kelly. Rummel suggested that Russian development of a Mach 2 transport might cost the U.S. prestige and loss of markets if we waited for the Mach 3 phase. If this happened, one solution would be to go all out on the higher Mach plane. Kelly found it "disappointing" that more consideration was not given to the Mach 2 airplane since it seems to offer less departure from the conventional, both operationally and structurally.

Recent contacts with engine builders, Kelly said, had led United to believe that a suitable civil powerplant for a Mach 2 aircraft, without the use of afterburning, "may be within the realm of early practicality." Fuel costs of a Mach 2 plane may be lower than the 60-70% of direct operating cost estimates for Mach 3 transport fuel.

• **Utilization estimates** for the Mach 3 transports were questioned by several airline executives. For example, Pennell of Boeing postulated a fleet of four airplanes flying between New York and Paris and achieving a 7½-hr. daily utilization with six round trips a day and long layover at New York. Utilization could be brought to 9 hr. a day by sandwiching in short Miami hops, as Pan American now does by leasing its Boeing 707-120s to National Air Lines. But Kaufman of PanAm felt that the 7½ hr. time utilization figure for the average airline might be "somewhat optimistic." Speeds of the supersonic transport tend to make its scheduling resemble today's short haul piston operations, Kaufman suggested. With only one to three hours flying time between landings, flying time is difficult to build up much beyond six hours on the average unless route pattern conditions are extremely favorable. This factor, Kaufman said, will deserve particular attention in economic studies of supersonic aircraft.

In this connection, Sebold's assumption of 3,000 hr. of yearly utilization was questioned by Birger Homer, director, project and development engineering for Scandinavian Airlines System. The supersonic airplane will differ from the subsonic in that it cannot be used efficiently on shorter routes while waiting for long-range schedules, which may be limited by passenger needs. Therefore airlines may have to accept a lower utilization for the supersonic planes with corresponding higher costs, Homer suggested.

• **Structural materials** for the supersonic transport will not pose a critical problem, according to Sebold of Convair, if material characteristics are used to best advantage. Above Mach 2, naked aluminum is out, but insulated or jacketed aluminum may serve at considerably higher speeds. Around Mach 3, titanium and steel offer about the same structural weight factors.

• **Automatic controls** will be important elements of the supersonic transport, but the airplane must be operable manually by its crew and have flight characteristics similar to subsonic aircraft.

• **Fuel reserves** may be less liberal with the Mach 3 airplane, according to Douglas. Instead of the hour's reserves with current transports, 15 min. of reserve fuel may be all the supersonic plane will tolerate economically. If holding times are to be reduced to cut necessary reserves, some new operational techniques will be required.

CAB Gives Tentative Approval To Airlines' Mutual Aid Pact

By L. L. Doty

Washington—Civil Aeronautics Board last week tentatively approved the mutual assistance agreement of six airlines as a financial protection against labor strikes but attached four conditions to the pact.

Meanwhile, labor leaders again raised protests against the plan, ranging from threats to turn to industry-wide bargaining to charges that the agreement repudiates the principle of conducting negotiations in good faith. The Board, however, found the mutual aid program during strikes not adverse to the public interest.

Under the original plan, strikebound airlines routed their grounded passengers to competing members of the pact.

In its decision, the Board conditioned its authorization of the agreement to require airlines hit by a strike to reroute passengers to all alternative services.

Here are the other conditions imposed on the carriers by the Board in its decision:

• **Pact must not conflict** with the "rights and duties of parties to airline labor disputes as provided by the Railway Labor Act." Air Line Pilots Assn. originally charged that the agreement repudiated the Railway Labor Act in that it bars the way to bargaining in good faith.

• **Board limited the effect** its decision would have on future rate-making proceedings. In this respect, the Board was serving notice that approval of passenger and freight tariffs and the setting of subsidies would not be affected by expenses or revenues resulting from the pact. The Board can be expected to take a closer look at the economic implications of the pact if it is invoked again at a future date.

• **Members of the agreement** will be required to report to the Board any modifications in the application or principles of the agreement, financial statements and the methods used for computing payments to strikebound carriers.

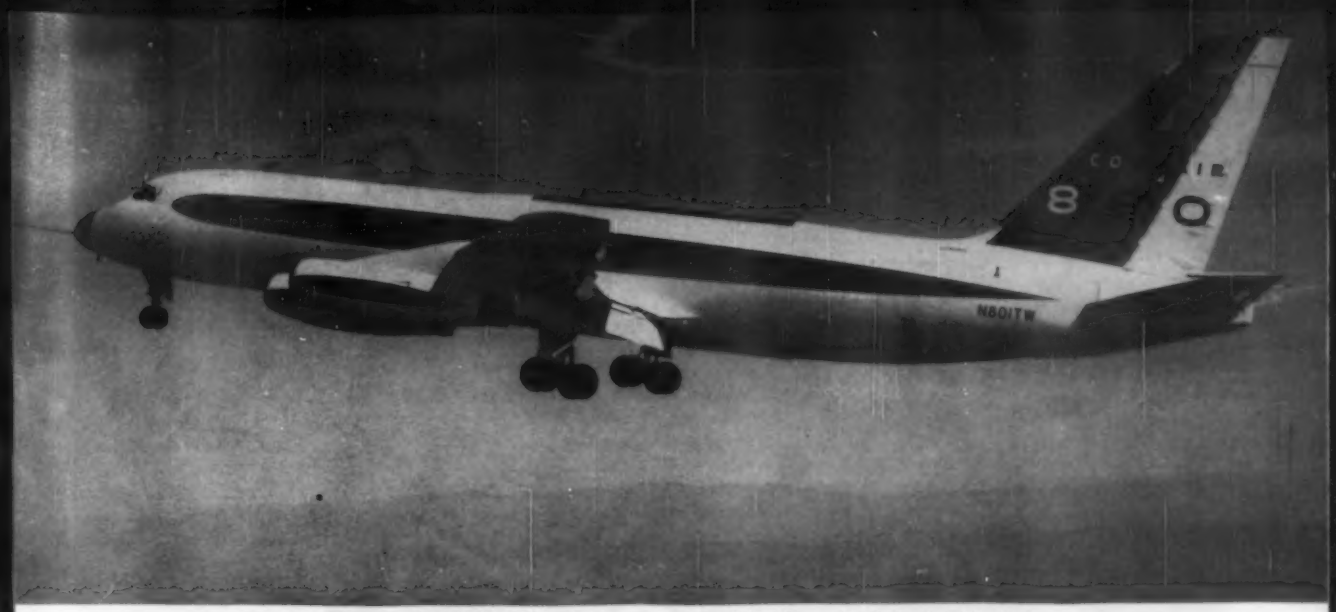
Announcement of the Board decision was not accompanied by a formal CAB order which will detail the agency's findings in the case. Vote on the issue was split by a dissent of member G. Joseph Minetti.

Members of the pact are American, Capital, Eastern, Trans World, Pan American and United Air Lines. The agreement was first applied when Capi-

American's Jet Service

New York—American Airlines last week began the first transcontinental scheduled jet service with capacity loads on its initial Boeing 707-120 flights and "extremely heavy" reservations for future schedules. First Los Angeles-New York flight time was 4 hr., 3 min. takeoff to tower, 4 hr., 23 min. ramp to ramp. First westbound schedule was flown in comparable times of 6 hr., 21 min. and 6 hr., 27 min.

The airline also has begun its Lockheed Electra turboprop service between New York and Chicago. Times of the first two flights: 2 hr., 43 min. ramp to ramp westbound; 2 hr., 5 min. ramp to ramp eastbound. Both flights were sold out.



Convair 880 Jet Transport Makes Initial Flight

First flight of Convair 880 jet transport was made last week from Lindbergh Field, San Diego, Calif., and lasted 1 hr. 14 min. Aircraft was airborne at 3,400 ft. mark and was accompanied by Air Force Lockheed T-33 chase plane. Maximum speed was held to about 300 kt. and top altitude reached was about 20,000 ft., according to Don Germeraad, pilot, and Phil Prophett, copilot. The 880 landed at U. S. Naval Air Station at North Island; aircraft will be based there for its first 10 flight hours, on arrangement with U. S. Navy and Federal Aviation Agency. Second Convair 880 will join flight test program in April and a third, scheduled for June, will be the first to have a completed interior. It will be used in simulated airline service flights and for air conditioning and acoustic tests. Aircraft is powered by four General Electric CJ-805-3 turbojet engines, commercial version of the J79 which powers the Convair B-58 Hustler.

tal Airlines was grounded by an International Assn. of Machinist strike from Oct. 17 to Nov. 22.

Under the agreement, Capital received a total of $2.2 million from the five member carriers for losses incurred during the period of the strike. Effect was to reduce the carrier's two-month net operating loss to $1.3 million The airline actually showed a net operating loss of $2 million for the period but, since it had projected a $1.5 million net operating profit for October and November under normal scheduled operations, the carrier estimates total net operating loss as a result of the strike at $3.6 million.

An estimated $5 million has been paid to Capital, Eastern and TWA, all hit by strikes since the agreement was reached. American Airlines, fourth carrier to experience a strike within the life of the agreement, has not received any financial assistance from pact members since it has not been determined that the carrier is entitled to aid under the provisions of the agreement.

The agreement requires that payments can be made only if labor demands exceed recommendations of a Presidential Emergency Board or are otherwise unlawful. No decision has been made as to whether American's strike with the Air Line Pilots Assn. meets these requirements.

American has refused to pay TWA its share of financial assistance created by the IAM strike against TWA until a decision is reached in its own case. Capital was asked to refund a $2,300 overpayment to member carriers.

The pact always has been open to all scheduled airlines. However, carriers now wishing to enter into the agreement must pay a pro-rata share of the amounts already distributed to strike-bound carriers before they may become members of the pact.

Stuart G. Tipton, president of the Air Transport Assn. called the Board's decision on the six-airline agreement a "noteworthy recognition of the airlines' efforts to minimize labor conflict" in the industry. He said such measures "should deter strikes and help restore true meaning to collective bargaining."

International Assn. of Machinists restated an earlier warning made in association with the Brotherhood of Railway Clerks that the agreement would "inevitably lead to a widening of labor disputes and the development of industry-wide strikes." During Board hearings on the pact, IAM urged the government to seize the airlines as it had done with railroads in the past during deadlocked strikes.

Air Line Pilots Assn. and Flight Engineers International Assn. both denied that any moves would be made to join the IAM in an industry-wide bargaining program. A spokesman for FEIA told AVIATION WEEK that his union would continue to reserve its right to strike against any or all of the contributing members of the pact.

ALPA said it would conduct all its bargaining on a "company-by-company" basis. It reaffirmed its stand that the six-way contract is illegal adding that, under the agreement, no safeguard exists to prevent misuse by a combine which might seek to destroy union activities.

The Board's finding that application of the agreement during strikes "is not adverse to the public interest" protects member carriers from risking prosecution under anti-trust laws. However, a possibility does exist that the decision could be reviewed by the U. S. Court of Appeals if the unions chose to appeal.

Increased Earnings Reported by United

Chicago—United Air Lines last week reported that revenues and net earnings for 1958 reached the highest level in the company's history.

Net profit for the year totaled $14.3 million, including $548,000 from the sale of aircraft, or earnings equivalent to $4.05 per share. Operating revenues amounted to $315.8 million and operating expenses totaled $286.3 million including depreciation charges of $28.8 million.

Last year, net earnings were $7.9 million including a $3 million gain from the sale of aircraft after taxes. United's operating revenues totaled $281.9 million in 1957 against operating expenses of $269.6 million.

RADIOPLANE RP-76 SIMULATES NEAR-SONIC ENEMY ...ARMY MISSILEMEN SCORE HIT IN FIRST FIRING!

Place: Red Canyon Range, New Mexico. Time: minutes after an RP-76 high-altitude air-launching by Radioplane personnel. Event: Army missilemen sight RP-76 simulating an enemy weapon system approaching at Mach 0.9. They fire—for the first time against an RP-76—score a direct hit.

Responsible: the men of Battery C, 1st Missile Battalion (Nike-Ajax), 56th Artillery, U.S. Army Defense Command; the men of Radioplane's contractor-operated flight service program, backed by the more than 2,500 Radioplane drone specialists who designed and produced the RP-76.

This Army-Radioplane achievement typifies the result of Radioplane teamwork with all of the U. S. Armed Forces. Other current examples in development: the supersonic USAF-XQ-4A weapon evaluation target drone and the U. S. Navy's XKD4R-1 rocket target, two more members of Radioplane's complete drone family.

RADIOPLANE

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Fare Case Unaffected by Jet Surcharge

By Robert H. Cook

Washington—Temporary approval of jet surcharges by the Civil Aeronautics Board (AW Jan. 27, p. 39) is not expected to have a direct bearing upon the outcome of the General Passenger Fare Investigation Case which, Board members indicate, may be decided by early summer.

However, the over-all question of jet fares and any difference between those and those levied piston engine fares, properly would be included in a second phase of the General Passenger Fare Case covering equipment requirements, according to Board spokesmen. Primary motivating force behind CAB's approval of extra jet fares for American and National airlines has been the need to accumulate a source of actual operational data on which to base a thorough study of the surcharge question, the spokesmen say.

The Board's action triggered an optimistic boost in airline stock with a rise of from 1 to 4¼ points among most major carriers following the Board's approval of a $10 surcharge for first-class jet service by National and a $3 to $10 extra fare for American. Also contributing to the stock rise was a later decision by the Board to approve application of the surcharge to American's coach service on the Boeing 707-120.

Market experts termed the increase "purely psychological" and pointed to a steady decline which began early last week, with only American and United retaining previous gains and continuing to rise. Bankers also were little moved by the market rise and have indicated that future financial backing will be influenced by the outcome of the General Passenger Fare Case and a searching analysis of commercial jet operations this year rather than by the surcharge approval.

Decision Date

While the Board could not pinpoint the date of a decision in the fare case, it pointed out that the expiration date for interim fare increases—totaling an estimated 10%—granted last February and October, is July 31. The outcome of the fare case is expected to be resolved prior to that date.

The date is also the same for the expiration of American's jet surcharge but was suggested by the Board only to reflect any possible fare changes that may arise from the General Fare Case, according to the Board. Pending future CAB action on the question of jet fares and differentials, American and other jet operators would be free to file for new jet tariffs or extension of present rates.

CAB estimates that it needs the results of at least six months of jet operations upon which to base any definite surcharge decision, even though it admits it is being pressed for a stand on this question by the International Air Transport Assn.

Last fall, IATA members disbanded a Cannes, France, meeting on the surcharge question after the Board took a neutral stand on the matter and refused to bend to the will of a majority of IATA members favoring the jet surcharge.

Now, the Board is again being asked to take a definite stand on this question at the Feb. 16 meeting of IATA in Paris (AW Oct. 27, p. 26). Informed observers are speculating that the Board's approval of American and National surcharges could influence the outcome of the international meeting.

Meanwhile, American has placed its surcharge on transcontinental coach and first-class flights, and National is offering a de luxe first-class jet service carrying a $10 surcharge and a "first class" service at first-class fare with no surcharge on its New York-Miami route utilizing a Boeing 707-120 leased from Pan American.

Unlike American, National did not file a tariff for jet coach service but elected to term its six abreast seating as "first-class jet service," which the CAB is now in the process of investigating. National's authority for a surcharge expires May 31 when the jet aircraft is returned to Pan American in accordance with the lease agreement between the two carriers.

The airline defends its first-class New York-Miami fare of $80.80 one way for the six abreast configuration on grounds that its relatively short route of 1,100 mi. is not only more costly to operate than the long haul transatlantic jet flights but is offered at a cents per mile basis almost identical with that of the economy class service on the transatlantic.

Eastern's Objection

Eastern Air Lines, in particular, has objected to National's advertising of "first-class" service and has asked CAB to investigate the matter. Advertisements in which National offered a choice of first-class seats at no extra charge, or de luxe at $10 extra, were termed "deceptive advertising" by Eastern attorneys, who contend that the seats are the same as those offered in Pan American's economy class seating with a 34-in. pitch and "under-sized" arm rests.

Replying to the filing, National answered that the first-class seating is the same as that employed by Pan American; the fare is almost the same as Pan American's economy fare per passenger mile; the seating offered contains more room since the jets are wider than piston aircraft.

National also reminded its competitor that the Boeing 707-120 load factor has been 90% during this month and that all passengers are informed "first-class" means a six abreast seating. Proper forum for the Eastern complaints, said National, is in the CAB investigation already under way.

RAF Britannia Tests Under Way

First Royal Air Force Bristol Britannia 253 taxis to ramp after test flight at Short Brothers & Harland's Belfast, Northern Ireland, airfield. Aircraft made its first flight at Belfast (AW Jan. 5, p. 27) and is the first of 15 Britannia 253s for the RAF; three 252s are being built for British Ministry of Supply. Aircraft is powered by four Proteus 255 turboprop engines, developing 4,445 eshp. each. Flooring has been strengthened for heavy military loads.

Preston Ball, left, chief of Martin reproduction department, and Parker Daggett, management engineer, compare with an original drawing the superb quality of a reduced-size copy run off from an offset paper master prepared by xerography. Original drawing was first microfilmed, then "blown back" by XeroX® Copyflo® 11 continuous printer onto a paper master for runoff on a duplicator.

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Democrats Push Airport Aid Measure

By Katherine Johnsen

Washington—Senate Democrats are pushing to have legislation that would provide $575 million in federal aid for airport construction to become the first measure passed by the new session of Congress.

Public hearings before the Senate Commerce Committee—at which several segments of aviation strongly backed the measure—were completed last week, and Sen. Mike Monroney (D.-Okla.), chairman of the aviation subcommittee, hopes to have the legislation ready for action on the Senate floor by Feb. 4.

In opposing the $575 million proposal sponsored by Monroney and over 40 other senators, the Administration offered a substitute providing $200 million. The proposal marked a retreat from the Administration's position of last year when former Under Secretary of Commerce for Transportation Louis Rothschild opposed any additional federal assistance for airport construction.

Based on Survey

The Administration proposal was based upon a survey by the Federal Aviation Agency which showed national airport requirements totaling almost $1.3 billion over the next four years. This would involve $725 million local financing under the Monroney measure, and over $1 billion in local financing under the Administration plan.

Republican reaction in Congress to the Administration proposal was unenthusiastic. Sen. Andrew Schoeppel (Kans.), ranking Republican on the Commerce Committee, suggested that "the best airport legislation may be one merging features" of the Monroney and Administration bills. Sen. Thomas Kuchel (Calif.), assistant Republican leader, is one of the sponsors of the Monroney bill.

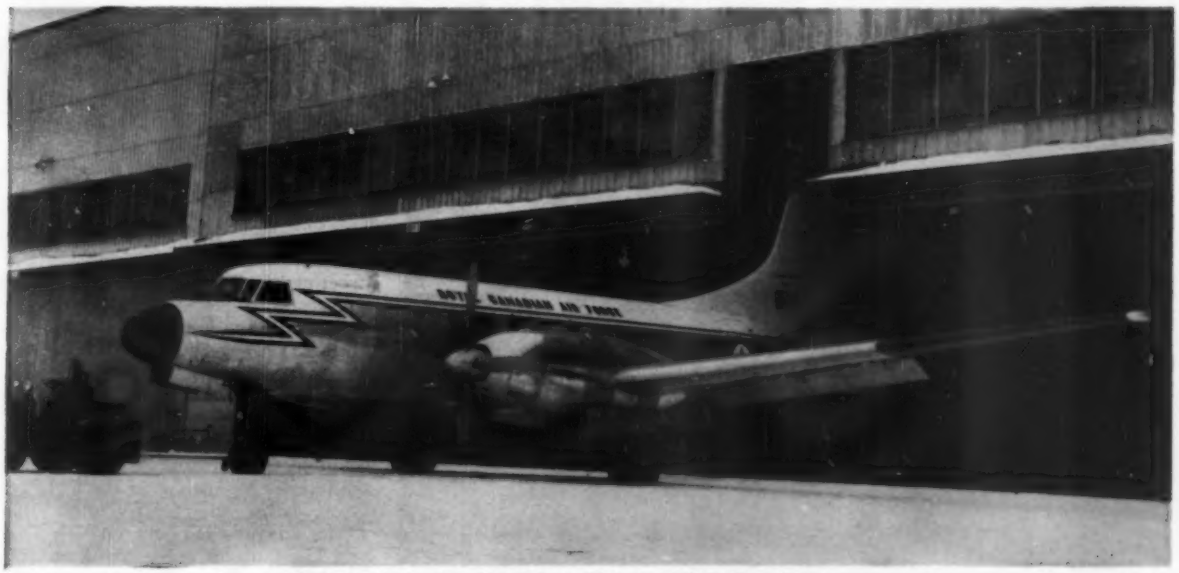
Counter-Proposal Details

These are the provisions of the Administration proposal, presented to Senate Commerce Committee by FAA Administrator E. R. Quesada:

- **Four-year extension of federal** assistance: $65 million in Fiscal 1960; $55 million in Fiscal 1961; $45 million in Fiscal 1962; $35 million in Fiscal 1963. The Monroney bill provides $100 million for five years, and an additional $75 million emergency fund to get an expanded program under construction. Present law provides $63 million a year.
- **Total of 50% of the funds** would be allocated to states under a formula giving weight to area and population, and 50% would be allocated at the discretion of the FAA Administrator to top-priority projects. Under the Monroney bill and under present law, only 25% of airport funds are discretionary. Increasing it to 50%. Quesada said, "would provide badly needed flexibility to meet urgent requirements where they actually exist."
- **Funds allocated to states but unused** after two years would revert to the FAA Administrator's discretionary fund. Under the Monroney bill and present law, unused funds would be reallocated to the states under the area-population formula. Quesada said that, since mid-1955, 14 states have never utilized all of the state apportionment funds available to them, while there were urgent airport financing requirements in other areas.
- **Federal funds would not** go "beyond the gates." They could not be used for such projects as terminal buildings, passenger and freight processing facilities. Monroney countered that such facilities contribute as much toward facilitating air commerce as the runways and taxiways.

Administration View

Quesada presented the Administration proposal as one that meets "the true needs for which the federal government should properly be responsible. It assures that federal participation will continue for the period necessary to afford ample opportunity to the states and local communities to assume their proper responsibility without disruption of needed airport development. At the same time, it reflects our conviction that the time has come for the



Canadair Rolls Out First 540 Turboprop

First Canadair 540 turboprop transport last week was rolled out at Montreal, Canada, in colors of Royal Canadian Air Force. Aircraft will be operated by RCAF Air Transport Command. Airframe is a new Convair 440, modified at Montreal to provide Napier Eland turboprop engines. Other changes are increase in fuel capacity from 1,730 gal. to 2,032 gal., improved braking and faster landing gear retraction.

federal government to begin an orderly withdrawal from the airport grant program."

The Monroney bill, Quesada said, "merely places a much higher dollar figure on an outmoded approach."

Other witnesses considered $575 million federal financing a minimum. Excerpts from testimony—all in support of the Monroney bill—include:

• **Air Transport Assn.** J. D. Durand, secretary and assistant and general counsel, said Quesada's proposal "obviously would represent a withdrawal by the federal government from the airport aid program, but it lacks any supporting data indicating that it would be an 'orderly' one . . ."

• **Assn. of Local & Territorial Airlines.** Joseph P. Adams, executive director and general counsel, noted that the DC-3 replacement programs of the local airlines "in every case will result in the use of larger aircraft requiring longer runways and more adequate airport facilities than are presently available in the majority of the smaller communities. To the extent that the new larger equipment will provide more efficient operations, the federal subsidy to the air carriers will be reduced."

• **National Business Aircraft Assn.** William K. Lawton, executive director, pointed out that of the 6,098 airports available for business aircraft users, only 1,016 have paved runways and are lighted.

• **General Aviation Council.** National Aviation Trades Assn. and Aircraft Owners and Pilots Assn. urged that more federal aid be channelled into small airports.

• **Airport Operators Council.** George Dement, vice president, reported that AOC members submitted requests for $129 million for Fiscal 1959 but received federal airport aid of only $29 million. The $175 million provided in the Monroney bill for Fiscal 1960, he said, "is not only justified but sorely needed, and we believe that the FAA could make almost immediate allocation of these funds." He said stability in civil airport development was "seriously endangered" by the President's veto of a similar Monroney bill last year.

• **States.** A. B. McMullen, executive director of National Assn. of State Aviation Officials, requested that there be federal aid of "at least $100 million" for 10 years.

• **Cities.** Mayor William Hartsfield of Atlanta, representing the U. S. Conference of Mayors, declared that "each time the airport question has come before Congress, the spokesman for the President has been against whatever was proposed . . . It is only within this week that the Administration has made its first proposal for airport aid and this proposal is woefully inadequate."

Examiner Raps Great Lakes Line

Washington—Compliance attorneys of the Civil Aeronautics Board are completing plans which they hope will break the "last of the big combines" of non-scheduled air carriers offering scheduled air transportation by what CAB terms illegal pooling of their trip authorities.

Action by CAB examiner Merritt Ruhlen, who recommended revocation of the interim supplemental certificates of Great Lakes Airlines Inc. and Currey Air Transport, Ltd., climaxed a running four-year battle which CAB's Office of Compliance has waged in an effort to stamp out violations of frequency and regularity of service, improper ticketing procedures and improper controls by and among supplemental air carriers.

During the past three years, the Board has succeeded in revoking the certificates of similar pooling arrangements by North American Airlines—including the 20th Century Airlines Inc., Trans American Airways, Hemisphere Air Transport and Trans National operating from coast to coast and the smaller Peninsular Air Transport Corp. and Aero Finance Corp. between New York and Miami.

Convictions on these violations eliminated these carriers from eligibility for interim supplemental certificates, which permit non-scheduled airlines to conduct 10 flights per month between any two points (AW April 14, 1958, p. 41) and presumably would eliminate Great Lakes and Currey from any permanent certification as supplemental carriers under the pending Large Irregular Case, according to CAB attorneys.

Along with the revocation recommendation, examiner Ruhlen also recommended a cease and desist order against six "Skycoach" agencies organized as independent ticketing agencies but which, the examiner claims, are controlled by Irving and Ida Hermann who own and control both Great Lakes and Currey.

Complaints filed by the Office of Compliance in the Great Lakes Enforcement Case charge that the Hermanns, through their companies and agencies, have willfully combined the trip authorities of Great Lakes and Currey to offer almost daily service on many route segments and aided the provision of such service by the advertising and ticketing facilities provided by the "Skycoach" agencies. Scope of the CAB's investigation covered the period from August, 1952, to January, 1955, during which, the attorneys say, the Hermanns realized profits of $1.4 million before taxes in 1953-55.

In reviewing their case against the combine, CAB attorneys say that a composite calendar analysis of the flights of Great Lakes and Currey show that service was provided between New York and Los Angeles every day from July 31, 1953, to June 30, 1954, with the exception of 66 days. The attorneys contend that the flights also operated into Philadelphia and Chicago to provide daily service to these cities.

Ansett-ANA Airways Electras on Line

Two new Lockheed Electras, being built for Ansett-ANA Airways of Australia, are well forward on Lockheed's Burbank, Calif., production line. Ansett will receive its first Electra in March. Next plane on line is for American Airlines; following is for Eastern Air Lines.

SHORTLINES

▶ **Aerolineas Argentinas** plans to inaugurate transatlantic and South America-New York service this spring using the first three of six de Havilland Comet 4 jet transports on order. The remainder of the Aerolineas' order is scheduled to be completed in 1960.

▶ **American Airlines'** board of directors has authorized payment of a dividend of 25 cents per share on common capital stock to be paid on Mar. 1 to stockholders of record on Feb. 13. The directors also declared the regular quarterly dividend of 87½ cents per share on 3½% cumulative convertible preferred stock also payable on Mar. 1 to stockholders on record on Feb. 13.

▶ **Federal Aviation Agency** Administrator Elwood Quesada has announced formation of a five-man committee composed of leaders of the aviation industry to advise FAA on matters pertaining to general aspects of aviation. The committee, which will serve for one year, will meet in Washington four or five times a year.

▶ **Flying Tiger Line** reports revenues of $6,833,550 for the six-month period ending Dec. 1. This represents a 40% gain over the same period of last year when the total was $4,780,464. December traffic reached $1,350,848 as compared with $839,520 in December, 1957, a gain of 60%. Calendar year 1958 revenue totals rose 25% to $12,-112,117.

▶ **KLM Royal Dutch Airlines** has received permission from the Soviet government to raise the number of flights between Amsterdam and Moscow from one to two flights per week. Aeroflot will also increase its flight correspondingly.

▶ **Seaboard & Western Airlines** flew 15 million ton miles of cargo and mail in scheduled transatlantic service during 1958, an increase of 21% over 1957.

▶ **Trans Texas Airways** reports that it flew 66,901 passengers 15,751,696 revenue passenger miles in the last quarter of 1958. December figures were 22,716 passengers boarded, a load factor of 45.37.

▶ **United Air Lines** has signed interline agreements with three South American carriers and two airlines serving Afghanistan and Australia. The pacts make possible passenger travel or cargo shipment over United's routes and those of each of the other lines with a single ticket or air waybill.

AIRLINE OBSERVER

▶ Long-awaited introduction of Lockheed Electra arrived without impact because of strikes and simultaneous inauguration of turbojet service. As a result, Eastern's first flights were slow-starters. For the first few days, average load factors on prime flights were in the 20s. Steady improvement has raised system load factor for the Electra to 52.5% compared with 45.35% for other aircraft. New York-Houston flight has been hitting 71%. One competitive flight with National's Boeing turbojet has moved to an 86% load factor.

▶ **Aeroflot, Soviet state-owned airline, will charter Tu-104 turbojet transports to two British travel agents this summer for 15-day package tours of Russia. Tours including hotels, meals, transportation and sightseeing, will cost $438 each. Agents claim Russian charter costs are comparable to fees covering British turboprop. Aircraft will operate from Stansted or Gatwick airports if permission to land at London Airport is not granted.**

▶ Boeing Airplane Co. is modifying 707 prototype by installing a glove on wing leading edge. Glove extends from inboard engine nacelle pylon to fuselage, forming obtuse triangle viewed from planform. Purpose of modification is to delay Mach drag rise, permitting either higher cruise, or same cruise at reduced power setting. Effective thickness of wing is not changed and only small increment of sweepback is added.

▶ **Airline issues on the New York Stock Exchange continue to show consistent strength, with Pan American, Eastern and American showing the biggest gains, an indication that turbine-powered equipment is appealing to the investor.**

▶ Civil Aeronautics Board admits pressure from airlines for a restatement of the agency's policy on the jet surcharge issue for North Atlantic flights (AW Jan. 19, p. 36) but is still undecided whether to enlarge upon its policy statement of September which the industry describes as vague.

▶ **Development of aircoach seating capacity on domestic trunklines during 1958 steadily outpaced first-class category. Volume of first-class seats offered during the year remained about the same during the first 10 months. However, aircoach capacity showed consistent monthly increases ranging from 10 to 23% except in November and December when both categories declined as a result of labor strikes.**

▶ Allegheny Airlines discount fare of 33⅓% offered groups of 10 or more passengers has created a new salesman for the carrier—the travel agent. Generally, travel agents show little enthusiasm for selling tickets on local service airlines because of the low return on commissions. However, Allegheny's plan offers the commission agent an incentive to plug local service travel.

▶ **Communist China's Civil Aviation Administration (CAC) plans to have at least 1,700 short-haul aircraft, mostly Soviet-designed An-2 biplanes, in local service by 1962. Around 60 of the planes will be allocated to each province. Red China built its first single-engine, 10-passenger An-2 in 1957, and the craft is now in quantity production.**

▶ No-show problem reappeared with the tight-space situation created during December by the grounding of American and Eastern because of labor strikes. Without any penalty control over the no-show, carriers were forced to encourage heavy airport stand-by traffic as a means of protecting load factors.

▶ **American Airlines has added about 350 lb. of insulation in the rear of its Boeing 707-120s to help reduce engine noise.**

▶ Large Irregular Case has grown two years old since the examiner's opinion was rendered in January, 1957. Oral arguments were completed in November, 1957, and the case presumably has been in the opinion-writing stage during the 13 months since then.

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Bristol Proteus first entered airline service less than two years ago. Overhaul life on the 705 series has now reached 2,000 hours—a rate of increase never before achieved by any other engine, piston or gas turbine

No engine of comparable power in service today has an overhaul life that even approaches this length. Annual engine overhaul costs for BOAC's Britannia 102 aircraft have now been cut by 75% since the aircraft went into service.

Continued development, even lower fuel consumption. Further increases will give Proteus even longer overhaul life, entailing even lower operating costs. In addition, new versions of this engine—which already has a lower specific fuel consumption than any other gas turbine in civil or military use—are now giving even more power at an even lower specific fuel consumption.

Over 2½ million miles a month in world service Every day, all over the world, Proteus-powered Britannias fly more than 80,000 miles (2½ million miles a month), carrying passengers in quiet, speedy luxury, carrying a great variety of freight loads, and bringing profit to operators.

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ENGINES LIMITED

Navy, USAF Spur High Heat Metals Tests

By Michael Yaffee

New York—Spearheaded by the Navy's Bureau of Aeronautics and the Air Force's Wright Air Development Center, the military's multipronged attack on the development of high temperature materials for future aircraft and missiles is gaining momentum and concrete objectives.

One of the most significant new developments in this field is the establishment of an Air Force program for the development of a 2,500F leading edge for hypersonic boost glide vehicles such as the Dyna-Soar. Contract calls for a heat-sustaining structure; that is, a leading edge which can maintain the required strength under anticipated reentry temperatures of 2,500F for periods perhaps up to 30 min. without the aid of cooling devices, which would entail fairly heavy weight and reliability penalties.

The contract also specifies use of existing structural materials in available mill forms. Prime contractor is the Space Flight Division of Bell Aircraft Corp. Bell's Wilfred H. Dukes, chief of structures on the Dyna-Soar project, is supervising the program which is scheduled to run to the end of the current year.

Here, briefly, are some of the other noteworthy developments that have taken place recently in the field of high temperature materials:

• **Bureau of Mines** scientists have succeeded in making the first molybdenum casting. Regarded as a major metallurgical breakthrough, the casting process will probably first be used to make rocket nozzles and, later, more complicated structures.

• **Scientists are making** significant progress in the fabrication of tungsten and believe they will be able to draw a one-piece leading edge suitable for hypersonic boost-glide vehicles in three to five years.

• **Protective coatings** for molybdenum are being developed in increasing numbers. High promise of some of the new ones coupled with commercial availability of molybdenum mill products makes the material the leading current candidate for aircraft structural applications at temperatures above 2,000F.

• **New vacuum arc** melting process has opened the door to production of large ingots of high purity tantalum. Improved ductility, lower cost and high melting point of the new material, say some metallurgists, makes tantalum an important contender among high temperature metals.

• **Continuing development** and improvement of methods for building stronger materials has led to three techniques which presently show much promise for high temperature structures. These are dispersion hardening, fiber reinforcement and sandwich structures.

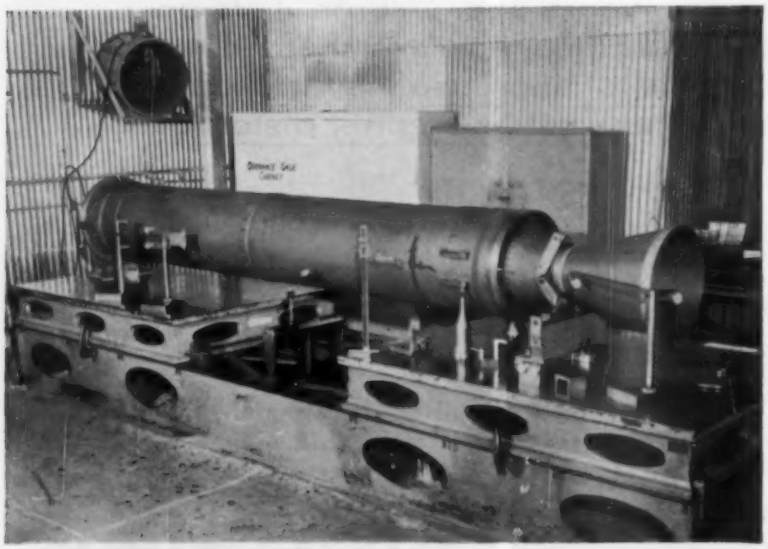
• **Recent discoveries** of extensive ore deposits have greatly boosted interest in niobium, which has a comparatively low density and promising high temperature properties. The metal, in fact, is now rated by some metallurgists second only to molybdenum as a current choice among refractory structural materials.

• **Researchers are investigating** a material with the highest known melting point of any solid—approximately 6,920F. It is a four to one mixture of tantalum carbide and hafnium carbide.

• **Extensive work** is now under way on the investigation and development of new alloy systems including such combinations of refractory metals as tungsten-rhenium and tantalum-osmium.

• **Experimental molybdenum** structures have been developed which have successfully withstood temperatures to 4,000F for brief periods without benefit of protective coatings.

• **Materials processing** is advancing rapidly. The development of new processing tools, techniques and facilities such as plasma jets, electron beam melting and the Navy's inert fabrication pilot unit is resulting in the production of purer, stronger and more workable metals and alloys.



Honest John Field Missile Inspected

Metal part assembly of Douglas Honest John surface-to-surface field missile is readied for inspection at the Orange, Tex., plant of American Bridge Division of U.S. Steel Corp. Unit is shipped to an Army arsenal after final inspection. Honest John has a 6,000 lb. launch weight, is powered by solid propellant rocket engine.

Structural Requirements

The reason behind this mounting metallurgical activity is the military's increasingly urgent need for new structural materials which can meet the design requirements of the future generations of aircraft.

The development of such materials is, in fact, considered by many engineers to be a prerequisite to the development of advanced aircraft. In the words of Maj. Frederick C. Krug, Headquarters, USAF Air Research and Development Command: "The revolutionary vehicles contemplated by the Air Force to maintain qualitatively superior airpower await revolutionary development of vastly new or improved lightweight reliable structural materials stable to the extreme punishment of these environments."

The environments referred to are those produced by extreme heat, high altitude, radiation and corrosion.

Of these, presently the best known and most pressing problems are created by the extreme heat that is anticipated during high speed flight.

The revolutionary military weapon

systems contemplated by the Air Force are broken down by Maj. Krug into three broad categories: hypersonic strategic vehicles, ballistic vehicles and satellite vehicles.

In the case of the hypersonic strategic vehicle as exemplified by the boost glide aircraft or the hypersonic bomber, flight times will be measured in hours, and speeds at the Mach 10-and-above level. And it is here that some of the most intense high temperature problems will be encountered.

Intense Heating

During the boost phase, the hypersonic bomber will be subjected to brief but intense aerodynamic heating that will thermally shock the structure. In the course of its flight, a large hypersonic bomber may have to sustain a total heat load of almost one million Btu/hr.

It will be soaked with temperatures above 1,000F, while maximum temperatures may approach 2,500F.

Another Air Force scientist, I. Perlmutter of WADC Materiels Laboratory, estimates that the stagnation temperature at the leading edge of a boost glide vehicle during re-entry may run anywhere from 2,260F for a vehicle with a 3-in. radius leading edge following a relatively low speed, re-entry flight profile to 4,090F for a vehicle with a 1-in. radius leading edge following a high speed, re-entry flight profile. The actual material temperature of the leading edge will be lower, of course, but only by an estimated 200 to 400F.

Not Now Available

There are no structural materials now available—and this includes the super alloys—which are capable of maintaining useful strength at these temperatures.

It is possible, of course, to design around the high temperature problem by using such schemes as regenerative cooling, insulation, heat exchangers, protective coatings, double wall construction, etc. These techniques are already being used in many missile and aircraft applications, and new methods for minimizing material temperatures are continually being investigated.

But in the case of the hypersonic bomber, as Maj. Krug points out, cooling of even the best heat resistant materials available today would entail almost prohibitive weight penalties in insulation, coolant and cooling equipment. In addition, the complicated plumbing and other involved aspects of such an arrangement would take a heavy toll in reliability.

What is needed, as far as the Air Force is concerned, are new frame and skin materials capable of maintaining their strength at 2,500F together with leading edge materials that can serve at higher temperatures. The Navy, somewhat more modestly, is calling for the development of new alloy systems for structural usage at temperatures of 2,000F and up.

The 500 deg. difference between the services in setting their lower limits is neither adamantine nor significant. The point is that both groups are looking for new structural materials to take over where the best of the presently available materials leaves off—somewhere close to 1,900F.

To get these new materials, the Navy and Air Force along with other government groups are sponsoring an extensive research program aimed at the development of the refractory metals, which many metallurgists consider to be the best structural bases attainable for extreme high temperature applications.

Douglas C-133 Airlifts Titan ICBM

Martin Titan intercontinental ballistic missile is loaded aboard a Douglas C-133 Cargomaster transport at Denver, Colo., for shipment to Cape Canaveral, Fla. Cargomaster is said to be first aircraft to airlift an ICBM.

Super-Temperature Metals

The refractory metals as such do not fall into a specific material group or classification. For working purposes, N. E. Promisel, head of the materiels branch in the Navy Bureau of Aeronautics, defines them as metals which have melting points above 3,000F. (For a rather rough approximation, metallurgists generally peg the useful operating temperature of a metal at slightly better than half its melting point. The use of alloying elements, often can extend this as high as 80%).

By virtue of melting point alone, well over a dozen metals then could qualify as refractory. From a practical engineering viewpoint, however, all but four or possibly five of these can be eliminated from serious consideration as potential base metals for extreme high temperature alloys systems, because of such factors as unusually high cost, small growth potential, unavailability, extreme brittleness or low strength.

This leaves tungsten, tantalum, molybdenum and niobium as the refractory metals of greatest current interest. Chromium, which falls just above the defined lower temperature limit and shows little growth potential, is also being given serious consideration because of its superior oxidation resistance. The others such as osmium, rhenium, ruthenium and iridium are being considered only as alloying elements owing to their scarcity and high cost. There is, for example, only .001 gram/ton of rhenium, rhodium, iridium, osmium or ruthenium available in the earth's crust as compared with 50,000 gram/ton for iron or 81,300 gram/ton for aluminum.

And the costs run from $500/lb. for ruthenium up to about $2,000/lb., for iridium.

Cost is always an important factor in the selection of a material, even in the manufacture of such exotic vehicles as hypersonic bombers. While it is difficult to set any exact figures, particularly in the case of weapon systems, a number of estimates have been made. One calculation is that a manufacturer can afford to pay $1,000/lb. for any metal that will save one pound of empty weight in the finished aircraft.

High Costs

Frederick D. Jewett, staff engineer at The Martin Co., and others in the aircraft field, say that the foregoing calculation is somewhat optimistic. Jewett says the aircraft industry cannot afford to pay more than $1,000/lb., installed, for any metal. By the same token, he calculates that the high in-

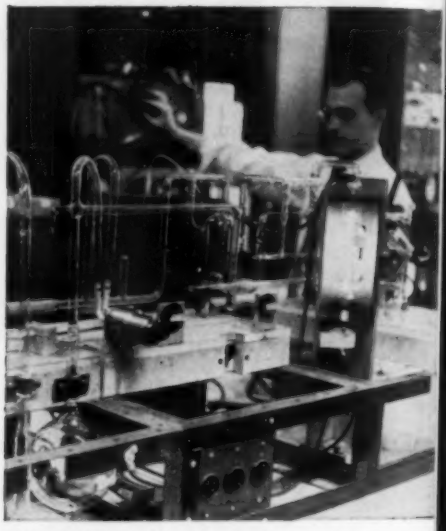
CAPABILITIES FOR DEFENSE

Westinghouse is spending $185 million for research and development in 1959

HERE ARE SOME CURRENT PROJECTS...

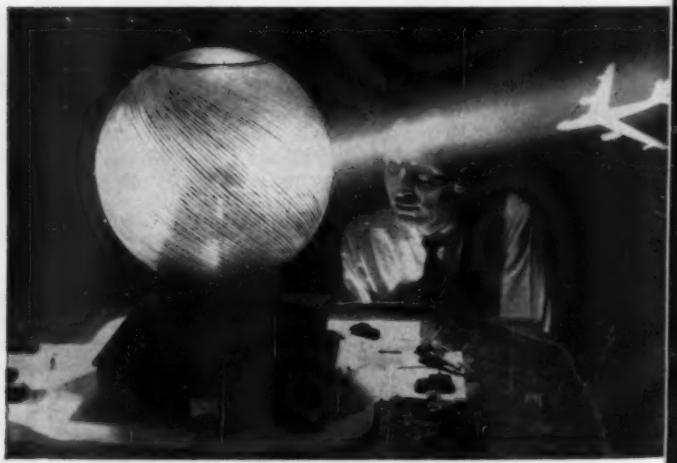
HIGH TEMPERATURE ELECTRICAL INSULATION. Effective for long periods at 500° C—eventual applications to 1000° C now contemplated. Demonstration motor shown above is running red hot. *Aircraft Equipment Department, Materials Engineering Departments, and Research Laboratories*

SPECIAL METALS. Westinghouse spearheads research in refractory alloys with one of the country's largest programs in special metals. Westinghouse is nation's principal supplier of a number of special defense-application metals. *Materials Manufacturing Department, Aviation Gas Turbine Division and Lamp Division*



HIGH-VACUUM RESEARCH. Extensive high-vacuum research conducted since 1947. Current areas of investigation include electrical and chemical pumping in ultra high-vacuum range and component development for large high speed pumping systems. Results being applied in advanced electronic device development. *Air Arm Division and Research Laboratories*

UNDERWATER SONICS. Current Westinghouse projects being conducted in laboratories and at sea are investigating various types of "scatterers" and their effect on the underwater transmission of sound. Also under development: acoustical torpedo controls and an acoustical mine identification system. *Ordnance Department and Research Laboratories*



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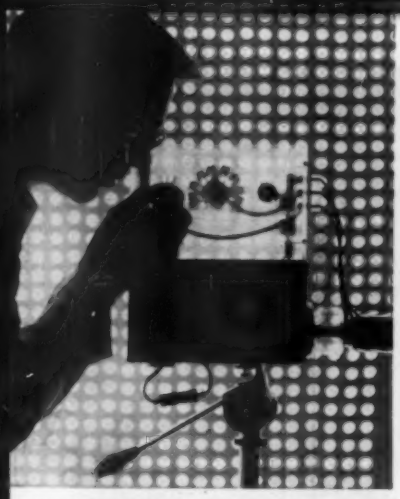
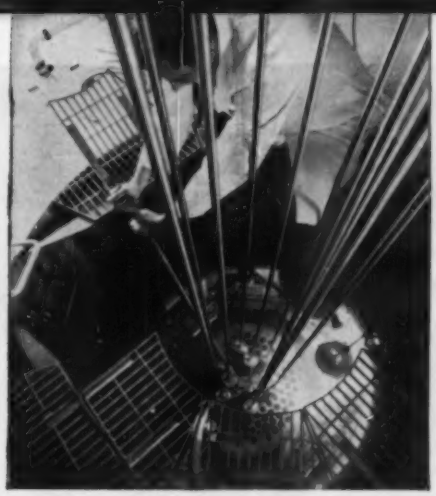


LIGHT AMPLIFICATION, through electron bombardment induced conductivity. Extremely sensitive. Principle especially useful for satellite reconnaissance devices. Efficient working models have been developed. ***Electronic Tube Division, Astronautics Institute and Research Laboratories***



NUCLEAR RESEARCH. At the Westinghouse Testing Reactor, engineers are preparing high intensity radiation tests on a wide range of materials to determine their structural, chemical, and nuclear stability. This is a necessary prelude to using these materials in certain atomic power applications now under development. ***Atomic Power Department***

INFRARED research projects include: *thermal imaging* — working models in advanced development; *ultrasensitive doped crystal detectors* — advanced test models; *photo-electric magnetic detection* — working model. ***Air Arm Division, Semi-Conductor Department, Materials Engineering Departments, and Research Laboratories***

PULSE-DOPPLER RADAR is in advanced development in three major areas of application at Westinghouse. Research is continuing to open up new potentials. Westinghouse is the acknowledged leader in this field. ***Air Arm Division***

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THERMOELECTRICITY. Westinghouse recently developed the first efficient material to produce electricity directly from heat at high temperatures (1100° C). In addition, other thermoelectric material under development can be used for cooling purposes, including very light-weight applications. Forty Westinghouse scientists now on this project. ***Materials Engineering Department and Research Laboratories***

LOW-NOISE MICROWAVE AMPLIFICATION. Westinghouse scientists have developed various low-noise solid-state amplifying devices, both MASER and non-linear reactance types. Progress in recent years was speeded by prior years of research in low-temperature and solid-state physics. ***Air Arm Division and Research Laboratories***

For information on these and other research projects, write to Mr. E. W. Locke, Director, Customer Relations, Westinghouse Defense Products Group, 1000 Connecticut Avenue, N.W., Washington 6, D. C.

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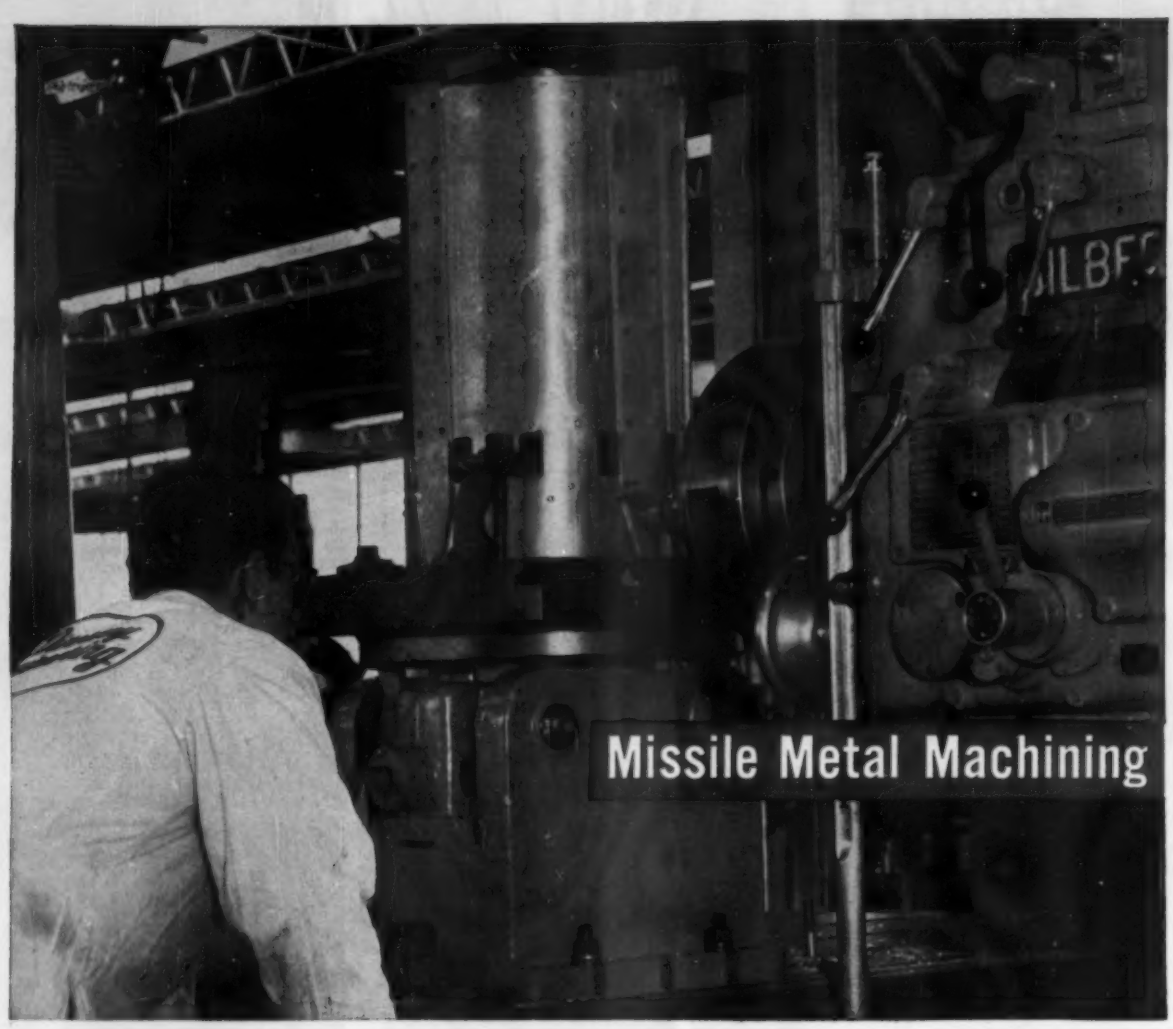

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stalled costs—in which he includes the the expense of safety measures required in fabrication, the difficulty of fabrication, etc.—of materials, such as beryllium and the rarer refractory metals will limit their use to specialized applications such as leading edges and heat shields where nothing else will do.

Molybdenum Technology

Of all the refractory metals, molybdenum is, perhaps, receiving the most attention today as a potential aircraft structural material. One of the major reasons for this is the great amount of work that already has gone into the development of the metal under the coordinated sponsorship of the Air Force and the Navy's Bureau of Aeronautics and Office of Naval Research since the Navy initiated its molybdenum research and development program in 1946.

As a result of this, molybdenum and molybdenum alloy technology is considerably more advanced than development of the other refractory metals. And at the present time, says the Navy's N. E. Promisel, molybdenum alloys exhibit the best over-all combination of properties of all the refractory metals for high temperature service.

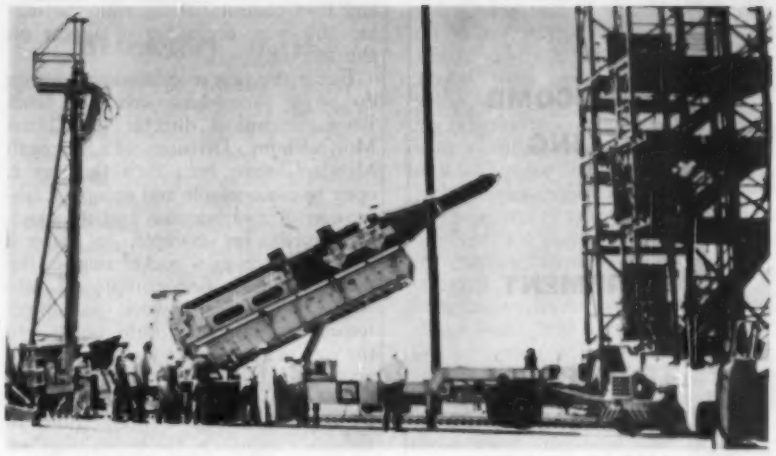
Today, molybdenum and molybdenum alloys are commercially available in many forms including plates, sheets, bars, wires and tubing. Costs are less—considerably less in many cases—than those of the other refractory metals; forging billets cast about $10/lb.; bar stock, $12 to $20/lb.; and sheet, anywhere from $20 to $60/lb. The metal is machinable and can be fabricated by the conventional processes of forging, rolling, drawing and spinning.

Molybdenum Casting

Recently, in what is regarded as a significant technological development, metallurgists at the Bureau of Mines laboratory in Albany, Ore., succeeded in making first molybdenum casting.

Initial castings are expected to be relatively simple rocket nozzle shapes, with more involved structures coming somewhat later.

This development, however, is still at a very early stage. So far, Bureau of Mines scientists have been working only with straight molybdenum and have not yet had a chance to experiment with the molybdenum alloys. Too, there is no way yet of telling what or how good the properties of the cast molybdenum shapes will be and this is the most critical factor in the evaluation of any fabrication development. The other thing to remember, say metallurgists, is that it was this same group which made the first successful titanium casting about two years ago



Transporter-Erector Positions Polaris

Mobile transporter-erector is used to position Lockheed Polaris AX-1 flight test vehicle at Cape Canaveral, Fla., launch pad (above). AX-1 test vehicles are the latest in a series of missiles developed for U. S. Navy by Missile Systems Division of Lockheed Aircraft Corp. Access tower at right is moved into position (below) when missile has reached its erected stage (AW Jan. 26, p. 27). Polaris is a solid-propellant fuel missile designed for a range of about 1,500 mi. and will be fired from under water. Of 26 Polaris test vehicle firings, 22 have been fully successful, Lockheed said.

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and that commercial titanium castings are only now beginning to appear on the market.

But if the new molybdenum castings do prove themselves, says Dr. Janet Briggs, technical director of Climax Molybdenum Division of American Metals Climax, Inc., then the way is open to more simple and economic fabrication of molybdenum and its alloys. At present, for example, to make a structure such as a rocket nozzle, the molybdenum is first compressed into large billets by powder metallurgy techniques or arc-cast into ingots. In the case of the powder metallurgy products, the billets are then sintered, forged into the desired shape, and the forging is machined to specification. In the other approach, the arc-castings are first extrtuded, then forged and machined. With the new casting process, a fabricator will be able to bypass the sintering and forging steps of the former or the extrusion and forging of the latter.

There are, of course, other fabrication problems that still remain to be solved.

Oxidizing Problem

Like most of the other refractory metals, molybdenum oxidizes rapidly at the elevated temperatures required for fabricating the metal in its true hot working range.

In an effort to solve this problem, BuAer recently awarded Universal-Cyclops Steel Corp. a $3-million contract for the construction of a pilot plant which will be used to develop methods of fabricating the reactive, refractory metals in an inert atmosphere (AW Dec. 8, p. 61).

The experimental Bureau of Mines castings are being carried out in an inert atmosphere.

The ready oxidation of molybdenum also constitutes the most serious drawback to the metal's use in high speed aircraft. In recent months, a number of groups including National Bureau of Standards, General Electric, National Research Corp., and Battelle Memorial Institute have developed protective coatings for the metal and its alloys. Some of these coatings, now under evaluation by the military, reportedly show much promise in extending the present temperature and time limits of molybdenum.

Turbine Applications

For some time now, aeronautical engineers have been very much interested in the use of molybdenum in gas turbine applications. Here, the problem of protecting the metal becomes even more difficult, for in addition to the oxidation problem, the metal is exposed to such factors as erosion, high stress and thermal cycling for extended periods. But even this problem seems to be on its way to a solution with word that General Electric has succeeded in running a jet engine with molybdenum turbine buckets, protected by a five-layer cladding, for more than 500 hr. at temperatures in the 2,000F region.

Short-Time Uses

But perhaps the most significant development in regard to molybdenum, according to a spokesman for American Metals Climax, a leading producer of structural molybdenum stock, has been the recent shift in interest from long time-moderate temperature applications to short, time-high temperature uses for the metal.

Unprotected molybdenum is now being used in rocket nozzles for short time service at temperatures "considerably in excess of 3,000F." Experimental units of molybdenum, still in the laboratory stage, have been developed which have withstood temperatures close to 4,000F for brief periods without protective coatings of any kind.

In the alloy field, American Metals Climax researchers have developed experimental molybdenum alloys with the extremely high 100-hr. rupture strength of 70,000 psi. at 2,000F. As a class, molybdenum alloys are superior to most other metals on the basis of their high strength-to-weight ratios at temperatures above 1,600F.

Another noteworthy event is a program now underway to develop molybdenum honeycomb for potential high temperature service in high speed aircraft wings. This program is still too early in development for any conclusive results, but its backers have high hopes for it.

Along somewhat different lines, Marquardt Aircraft is planning to build a molybdenum ramjet engine. Design speeds are expected to result in material temperatures above 2,000F.

Molybdenum Leading Edge

Of all the potential aircraft applications of molybdenum, it is the possible selection of the material for use in the Air Force's 2,500F heat-sustaining leading edge program that is, perhaps, currently generating the greatest interest, particularly among molybdenum manufacturers who would like to display their wares in this hypersonic showcase.

There is little doubt that the metal could take the 2,500F temperature. The question, says Bell Aircraft's Wilfred H. Dukes, is "how long can molybdenum take it?" Depending upon man's ability to withstand deceleration forces, the re-entry phase for a boost glide vehicle such as the Dyna-Soar may last anywhere from 15 to 30 min. And for periods this long, Dukes doesn't consider molybdenum a good candidate, at least not without some better protec-

tive coatings than he has seen to date. (Not to dismiss some of the newer molybdenum coatings too lightly, Dukes points out that coatings suitable for one application often may not be suitable for another, particularly one such as a leading edge.)

At the same time, Dukes admits, if he were forced to make a choice now among the refractory metals for his leading edge, he would choose molybdenum first and niobium, perhaps, second.

Niobium has better oxidation resistance than molybdenum, but its strength falls off faster at elevated temperature. At 3,000F there is little question that molybdenum would make the better structural material, says Dukes; and at 2,500F, he would still prefer molybdenum for its strength. But at this point, he says, the choice starts to get fuzzy and could go either way, depending upon whether the engineer prefers molybdenum's strength or niobium's oxidation resistance for his particular need.

Its high density—about 60% greater than that of molybdenum and almost 100% more than that of niobium—argues against the use of tantalum. And in the absence of any strong offsetting advantages, Dukes sees little point at this time anyway of giving the metal much thought as a leading edge candidate. Similarly, chromium is being given little consideration by Dukes, due primarily to the lack of commercially available mill forms and its doubtful performance at temperatures as high as 2,500F.

Tungsten he would have to consider unacceptable at this time because there has been no real work done on developing protective coatings for the material. On the other hand, given three to five years in which to make the choice of the best heat sustaining leading edge material, Dukes says, it should prove interesting and worthwhile to work on protective coatings for tungsten. In this period, with anything like the effort being spent on molybdenum coatings, he believes researchers could come up with a coating that would protect tungsten and make it the best choice for a high temperature leading edge.

There are, of course, other problems involved in a program such as this one; for example, there is a critical lack in essential data on these comparatively little known metals which among other things leads to a lack of uniformity in the properties of materials. Too, conventional design ideas, in many instances, no longer hold for these materials; engineers must be prepared to throw away "the book" and follow as their individual programs dictate.

There are also the problems of high cost and difficulty of fabrication. But Dukes doesn't consider any of these obstacles insurmountable; and, he points out, when you require the unusual properties offered by the refractory metals, you must be prepared to pay somewhere along the line.

The attraction of tungsten, of course, is its high melting point—the highest of any known metal. As a pure metal, says Dr. Russel H. Atkinson of Westinghouse Electric Corp., tungsten has the best high temperature properties of any

Refractory Metals

	Melting Point (F)	Density (gm/cm³)
Tungsten	6,152	19.3
Rhenium	5,756	20.0
Tantalum	5,425	16.6
Osmium	4,892	22.5
Molybdenum	4,752	10.2
Ruthenium	4,532	12.2
Iridium	4,449	22.4
Niobium	4,379	8.6
Rhodium	3,571	12.4
Vanadium	3,452	6.1
Chromium	3,434	7.2

Selected refractory metals (above) have been marked by military for accelerated research on basis of their promise as aircraft structural material for service at temperatures above 2,000F.

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of the refractory metals for structural applications at temperatures above 2,500F and below its melting point. Dr. Atkinson is working on the problem of realizing these properties with the aim, eventually, of making tungsten a practical alloy base for high temperature aircraft structural materials.

This could prove to be a hard job and a fairly long one. Westinghouse has established base line data on the metal at various purity levels and at temperatures above 2,200F. Its present contract with the Air Force calls for making the properties of tungsten more attractive at 2,500F. The next step is expected to be alloy development and after that will come learning how to form the metal into desired shapes.

For a long time fabricators have been drawing tungsten into wire filaments. But it has been only comparatively recently that companies—notably American Metals Climax, General Electric and Westinghouse—have learned how to make milled and cast tungsten products. This is opening up a field of shapes that was never open before and also a lot of problems.

Tungsten Hard to Work

Tungsten's high strength, an important structural advantage, proves a disadvantage when it comes to finding other materials strong enough to be used in the shaping of the metal. The ready oxidation and reactivity of the metal at high temperatures also makes it difficult to hot work the metal at the proper temperatures. The inert fabrication facility now under construction for the Navy should help solve some of these problems.

At present, Dr. Atkinson says, no one has the equipment or techniques for fabricating tungsten in large sizes. Both will have to be developed. But the very high costs that are anticipated for large tungsten fabrications will probably make them prohibitive for anybody but the military. Thus, Dr. Atkinson points out, any company that takes a contract to develop techniques and equipment for fabricating large tungsten shapes will do so with a close eye to potential purchase orders.

Dr. Atkinson believes that tungsten has an excellent chance of being chosen as the heat sustaining leading edge material, but a lot of work will have to go into the field first. Drawing a wire filament is one thing; rolling or forging a leading edge for a vehicle such as the Dyna-Soar is quite another. A big problem, for example, will be in trying to roll or forge it in one piece so as to avoid a patchwork affair that must be joined together. By piling the work on, however, Dr. Atkinson believes it would be possible to have a suitable tungsten leading edge within three years.

Like Fred Jewett of Martin, Dr. Atkinson sees the high-priced refractory metals only as specialty materials, limited mostly to applications where no other material will do the required job. To some extent, this is becoming true for all aircraft materials. The time has passed when one material can dominate the aircraft field as aluminum did in the past. Today, he says, different materials are selected for the temperature ranges they can best serve.

The particular application range for tungsten, as he sees it, is quite large. Starting at 2,500F, by proper alloying, he says, it will prove possible to extend tungsten's useful temperature range to within 75% or 80% of its melting point, that is, almost to 5,000F. With the possible exception of graphite and the refractory interstitial compounds such as transition metal borides and carbides, there is nothing else that can stand up to these temperatures. And while tungsten is considered very brittle, the cermets are considered even more so, showing up very poorly in regard to thermal shock, mechanical shock and notch sensitivity. Where materials are required for application at temperatures above 5,000F, of course, it may well become necessary to put up with the disadvantages of the refractory cermets.

As far as tungsten's high density goes, Dr. Atkinson and others don't consider it a major drawback. They feel that the material's high strength will permit the metal to be used in very thin, lightweight sections.

Everybody is impressed by niobium (or columbium, as it is often called), declares Dr. Atkinson, as long as they stay within the temperature limits of the material.

It is fairly generally agreed that 2,500F is just about the upper limit for the application of niobium, while the more favorable temperature range for the use of niobium or niobium alloys may be around 2,000-2,200F. It is in this lower range that engineers are now giving serious thought to the use of niobium alloys in jet engine buckets. At 2,000F, it is felt that niobium's strength is competitive with that of molybdenum while the higher oxidation resistance of its alloys gives it a definite advantage over the latter.

Until recently, the apparent scarcity of the metal proved a major drawback to its development. Now, however, discoveries of extensive ore deposits of the metal are generating growing interest in niobium.

E. I. du Pont de Nemours and Co., Inc., for example, recently announced the development of high purity niobium and new high strength niobium alloys which are being produced in experimental quantities. In the hope of stepping up production of the materials, du Pont has signed an agreement with Thompson Ramo Wooldridge for a joint development program aimed at exploiting the metals potential in aircraft and missile applications. Du Pont will supply Thompson with new niobium alloys and Thompson will develop forging and other fabrication techniques for the metals to fit them for the aircraft industry.

Major Interest

Another company with a major interest in the commercial development of niobium (and most of the other refractory metals) is Fansteel Metallurgical Corp. which has been supplying niobium in the form of powder and vacuum-sintered bars for some time now to those who are interested.

Kept reasonably free of the common gases—nitrogen, hydrogen and oxygen—which tend to embrittle the metal, niobium displays unusual workability, according to du Pont metallurgists who have reported cold-rolling of a 1 lb., ¾-in. niobium ingot into foil .001-in. thick without annealing.

Like the other refractory metals, niobium requires some protection against oxidation at elevated temperatures. While its strength falls off rapidly at elevated temperatures, its low density—lower than that of all other refractory metals except chromium—keeps the material fairly competitive with the other metals at temperatures in the neighborhood of 2,000F.

Phase diagram studies on niobium binary systems have up until now been prevented by the low quality of available material. The advent of high

IAF Congress

Tenth Annual Congress of the International Astronautical Federation (IAF) will be held at Church House, Westminster, London, S.W., England, during the week of Aug. 31-Sept. 5, 1959. Dr. L. R. Shepherd, of the British Interplanetary Society, will be chairman of the hosting society.

Andrew G. Haley, Washington, D. C., is president of the IAF for 1959. Vice presidents are: Paul J. Bergeron, Societe Francaise d'Astronautique, Paris, France; Dr. Eugen Sanger, Deutsche Gesellschaft fur Raketentechnik und Raumfahrt, Stuttgart-Flughafen, West Germany; Academician Leonid I. Sedov, Commission on Astronautics, Academy of Sciences, Moscow, USSR; Dr. L. R. Shepherd, British Interplanetary Society, London, England; Prof. T. M. Tabanera, Asociacion Argentina Interplanetaria, Buenos Aires, Argentina; and Prof. K. Zarankiewicz, Polskie Towarzystwo Astronautyczne, Warsaw, Poland. Dr. J. A. Stemmer, International Astronautical Federation, Baden, Switzerland, is secretary.

purity niobium now makes such studies—essential for gathering important fundamental data on material properties—possible and should lead to significant new information on the metal.

In a recent study on the development of niobium base alloys conducted for WADC by Richard T. Begley of Westinghouse, the author concludes that the recrystallization temperature range, an important factor in determining the high temperature strength properties of metals and alloys, of commercially pure niobium is approximately equivalent to that of unalloyed molybdenum. Begley's commercially pure material, however, had a relatively high zirconium impurity which was found to have a pronounced effect in raising the recrystallization temperature of the niobium.

Tantalum's Characteristics

Tantalum, the sister element to niobium, has already found applications in the chemical industry because of its high resistance to chemical corrosion and in the electronics industry because of its high di-electric value. But it has so far had few uses in the aviation field.

Like niobium, tantalum has a relatively low modulus of elasticity/density ratio. Unlike niobium, it is very heavy. It is almost as heavy as tungsten but does not offer the same high strength advantages that the latter does. And while it has good corrosion resistance, like the other refractory metals, tantalum needs high temperature protection against oxidation.

Too, until recently, tantalum has been available only in small ingots produced by vacuum sintering, resulting in high fabrication costs. Now, however, National Research Corp. is producing large (110-lb.) ingots of high purity tantalum that are expected to significantly lower fabrication costs. The high purity of the ingots also results in greater ductility of the metal, says National Research, which permits the ingots to be reduced to ½-mil-thick foil without intermediate annealing.

Tantalum's corrosion resistance is of some interest to the aircraft industry and has led, in a rather recent development, to the metal's use in rocket nozzles.

However, Dr. James H. Gardner of National Research Corp. believes that tantalum's extreme ease of fabrication—in large measure a result of the improved ductility of the new high purity ingots now being produced—in combination with its high melting point makes the metal attractive for all applications above 3,500F. Although there has been no actual experimentation yet, says Dr. Donald J. McPherson of Armour Research Foundation, tantalum alloys may prove stronger at very high temperatures than any prospective structural metal except tungsten. With the recent award of contracts for work on tantalum alloys, Wright Air Development Center is beginning to take a serious look at the metal.

Both chromium and vanadium fall close to the lower temperature limit arbitrarily set for refractory metals. Heretofore, there has been little interest in the development of these metals which have proven extremely brittle in the forms that have been available.

Pure and Ductile

Recently, vanadium has become available in a fairly pure and ductile form. This may lead to greater interest in the metal which is still being produced only in small quantities and at fairly high prices. However, vanadium still oxidizes almost catastrophically, at temperatures above 1,225F. While alloying is expected to improve its high temperature strength, it is believed that the material will still require the development of good protective coatings before any serious interest is generated in the aircraft industry over the metal.

Chromium, on the other hand, is receiving some attention from the industry owing to the superior oxidation resistance of its alloys, and a research program is now underway on the development of chromium and chromium alloys. However, Begley of Westinghouse feels that the generally poor workability and low ductility of chromium base alloys still presents serious obstacles to their engineering application.

In any case, as WADC's I. Perlmutter points out, insufficient growth potential will eliminate both metals from serious consideration as refractory materials, at least for the time being. Any potential structural applications for either metal probably would be well under the 2,000F. mark.

Too Expensive

The rest of the refractory metals—rhenium, osmium, ruthenium, iridium, and rhodium—are much too scarce and expensive to be considered for use in a pure state as structural materials. However, many of them have been attracting a lot of attention of late for their potential value as constituents in high temperature alloy systems.

Recently, for example, an alloy was developed consisting of 35 atomic percent rhenium in molybdenum which, says the Navy's N. E. Promisel, produces a promising high strength material with a high recrystallization temperature and low ductile transition temperature. Also, the new alloy is both cold and hot workable.

Examples such as this have encouraged the military to sponsor fairly extensive research on alloy development involving the refractory metals. Much of this is still of a rather basic and preliminary nature. Under an Air Force contract, for example, Nuclear Metals, Inc., is doing phase diagram studies on tungsten-ruthenium, tantalum-ruthenium and tantalum-osmium systems. Others are doing phase diagram work on tantalum-rhenium, tungsten-rhenium, tungsten-osmium, molybdenum-hafnium, molybdenum-hafnium-rhenium, niobium-rhenium and tungsten-hafnium systems.

Phase diagram studies, as Lester Klein of Nuclear Metals explains them, constitute fairly basic metallurgical research. They are good, almost essential starting points for work on any alloy system. They provide the metallurgist with a great deal of fundamental data; and, most important, tell him whether it will be useful or worthwhile to investigate a particular system.

There is also, of course, work being done on alloying the refractory metals with conventional metals. Most advanced to date are the alloy systems based on molybdenum. Of these, the molybdenum-titanium combinations have been studied most extensively, resulting in data that indicated a 0.5% titanium alloy as the optimum strength composition. This particular alloy is now in commercial production.

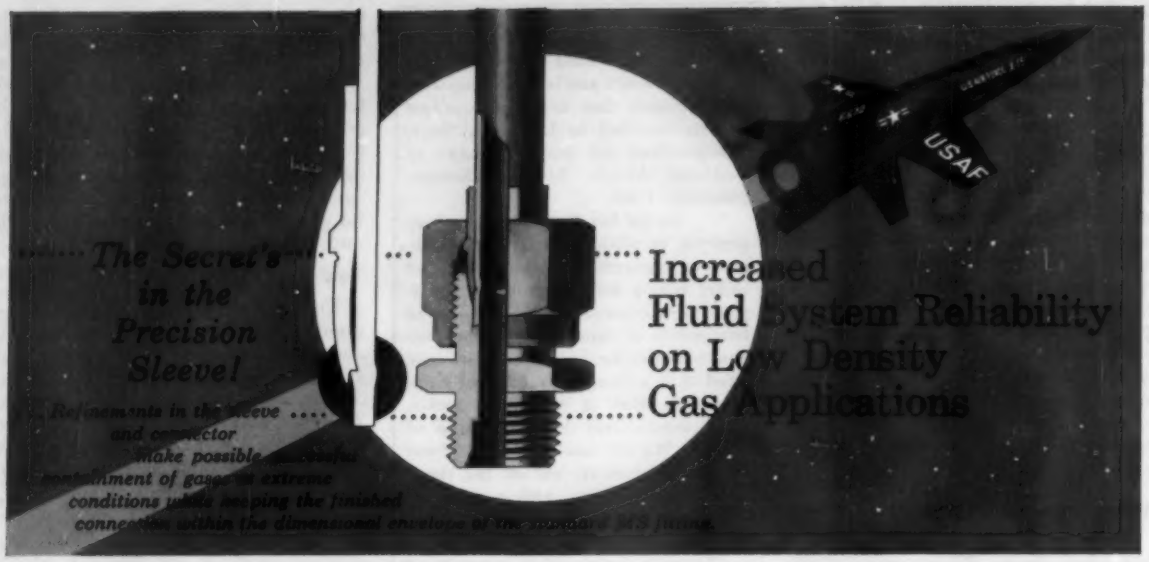
In addition to strengthening the refractory metals by conventional alloying techniques, says Promisel, metallurgists are now investigating the

Polaris Thrust Cutoff

Los Angeles—Thrust cutoff in solid-propellant rockets can be controlled with more precision than in liquid-propellant rockets, according to L. Eugene Root, vice president and general manager of Lockheed Missile Systems Division, Sunnyvale, Calif.

". . . In the last few months we have gone far in solving the technical problems of converting the early solid-fuel rocket into a fully controllable powerplant. For example, in the problem of termination of thrust at the correct instant to obtain the desired range, we were faced with a completely different situation from that of the liquid rocket, which requires only the timed shutoff of a valve. We can now, as a result of our recent developments, cut off the thrust of a solid fuel motor with even greater precision than any liquid rocket we know of.

"The use of the rocket motor thrust for control is particularly significant in the Polaris vehicle, since the necessity for underwater launch has compelled us to use a bird which is aerodynamically unstable . . ." Root declared at the charter meeting of the New Channel Cities section of the Institute of the Aeronautical Sciences, in Ventura, Calif.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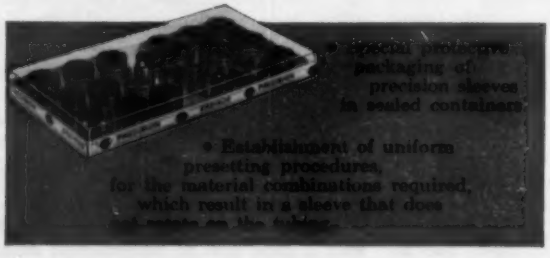
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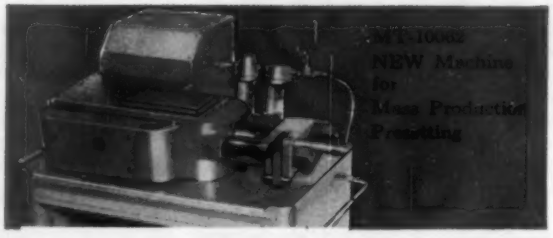

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application of dispersion hardening for increasing the strength of the refractory metals. This technique, which involves dispersing a powdered metal oxide through a metal matrix, was developed and first used in connection with aluminum. Now it has been found that the same principle, using oxides such as aluminum oxide, titanium oxide and zirconium oxide, works with a molybdenum matrix.

The dispersion-hardened molybdenum alloys appear particularly outstanding in their retention of short time tensile strengths at very high temperatures. Scientists see no reason why dispersion-hardening won't work with most of the other refractory metals. BuAer now has research underway on dispersion hardening involving borides and carbides as well as the oxides. This approach has received only preliminary attention so far, says Promisel, and substantial gains may be anticipated from the proper combination of dispersed phased and solid solution strengthening.

Refractory metals, of course, are not the only answer to the aircraft industry's high temperature engineering problems. There are other materials and approaches which may prove superior to the refractory metals or serve as important adjuncts to them.

Graphite, for example, retains mechanical properties to almost 6,000F and, at temperatures above 4,500F, is superior in strength properties to molybdenum and other of the refractory metals. The ready oxidation and erosion of graphite still remain major problems, but there is a good possibility that protective coatings can greatly ease these problems.

The ceramics and cermets have been receiving increased attention over the past decade for their potential as high temperature materials. Development of a 4-to-1 tantalum carbide-hafnium carbide mixture provides metallurgists with a material having approximately a 7,000F melting point, the highest of any known solid under normal conditions. At the same, these materials as a class still suffer from high notch sensitivity, low impact resistance, general lack of ductility and erratic thermal shock resistance. However, says Promisel, they still show some promise in applications where small sizes and cautious design are possible.

Of all these other approaches, it is the composite materials or structures, perhaps, which offer the most promise for high temperature structural applications.

It is difficult to define composites other than to say that they are mixtures of materials so designed as to optimize certain characteristics such as lightness and stiffness as in the case of the honeycomb structural sandwich. Reinforced plastics is another good example of composites.

This reinforcement aspect of composites appears most attractive to structural engineers. One of the more interesting applications of this principle from the aviation industry's point of view is the use of glass fibers to reinforce aluminum. An alloy known as Glass 2014 in which 20-60% fine glass fibers are used to reinforce the matrix of 2014 aluminum alloy is already available and is reported to have "engineering applicability" almost up to the melting point of the aluminum alloy.

For true high temperature applications, there is work now going on in embedding molybdenum wires and powders in oxidation resistant matrices. The hope is that even if the outer layers fail, underlying layers of protected molybdenum will appear and act as repeated "inner lines of defense". Somewhat the same idea, says Promisel, is behind the incorporation of molybdenum and other refractory metal wires into titanium in an effort to build a composite which will have good mechanical properties at temperatures above the current useful range of titanium.

Another potentially valuable type of composite is the multilayer configuration. Several possible configurations of this type have been proposed and are under investigation. One of the more interesting of these, according to Fred Jewett, involves the use of a conventional basic structure fabricated from, say, aluminum or steel on the inside combined with an outer structure made of one of the refractory metals such as tungsten or niobium, with the possibility of circulating a cooling fluid between the two layers. Joining the two layers together is expected to prove a sizable problem; and, in fact, Jewett believes, that fastening in general will prove a major problem with most of the new, high temperature structural materials.

Then there are the many heat-reducing techniques designed to keep material temperatures down to the toleration point. These include such things as regenerative cooling, heat exchangers, insulation, use of coatings to control emissivity, heat sinks, etc. Eventually, all advanced aircraft will probably require the extensive use of at least one of these approaches and possibly a combination of them. Consequently, the military is continuing to explore and develop this approach.

But it is on the refractory metals, that a large segment of the advanced design group is currently pinning its hopes. There can be no doubt, says Navy's Promisel, that the refractory metals exhibit great capabilities for fulfilling the requirements for high temperature structural materials and recent studies indicate that the full potential of these metals is still to be developed.

Black Knight Has 19,000 lb. Thrust

London — Thrust of the four "Gamma" rocket engines in Britain's Black Knight re-entry test vehicle is 16,400 lb., rising to 19,100 lb. as the back pressure falls, according to Armstrong Siddeley, Ltd.

Total weight of the thrust chamber in the vehicle is only 700 lb. which Armstrong Siddeley says is considerably less than that anticipated in the original vehicle design.

Oxidant used in the Gamma engine is hydrogen peroxide (HTP) and the fuel is kerosene.

The motors used in Black Knight (AW Sept. 22, p. 50) are modified versions of a unit developed in 1955 by the Royal Aircraft Establishment's Rocket Propulsion Department at Westcott. The Gamma engine is believed to be the largest of a family of aircraft-rocket motors designated at that time by Greek letters in the Westcott development program.

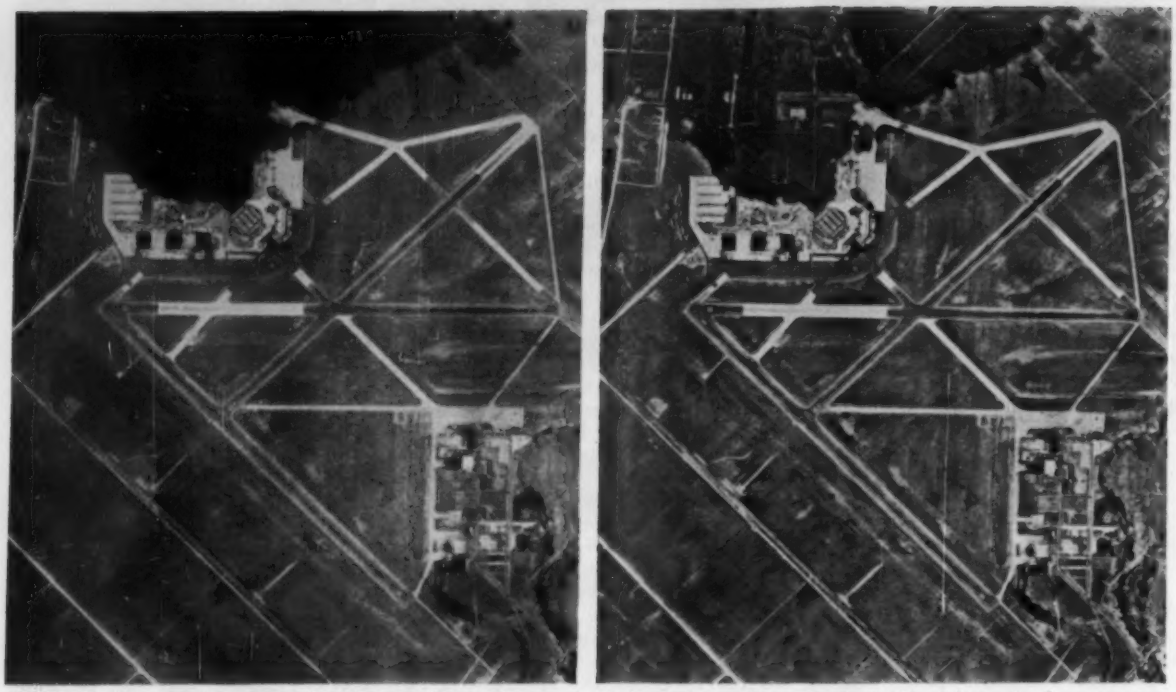
Whether or not it was the largest engine available, the use of a cluster of smaller engines has led to a method of directional control which obviates the engineering complexity of a gimbel mounting.

The four motors in Black Knight are arranged around the central vehicle support and are mounted on trunnions. The thrust line of each motor is displaced by a hydraulic actuator. For pitch control, a diametrically opposed pair are moved together. Yaw control is effected by movement of the other pair. Any tendency to roll is corrected by moving all four engines in the same direction. The clustered thrust system of Black Knight is also favored by the square cube law, but it has the disadvantage that there are more components to possibly malfunction.

Each motor has its own turbopump unit which feeds the propellants through the hollow trunnion mountings. The HTP and kerosene centrifugal impellers in the pump units are mounted on either side of an axial flow turbine which is driven by steam from HTP decomposed in separate catalyst packs.

All four turbopump units are connected rigidly to the vehicle structure and are served by a common HTP manifold.

Hydraulic control system is pressurized by pumps driven through kerosene-lubricated reduction gearing by two of the turbopump units.



PRINCIPLE of image enhancement of aerial reconnaissance photographs by increasing small area contrast without increasing large area contrast is shown above. Conventional photograph (left) contains vital information in an area covered by cloud shadow. Enhanced picture (right) makes recognizable objects in the shadow and has four times the mid-tone contrast, making small objects easier to see.

Satellite Reconnaissance Optics (Part III):

Improving Image Aids Reconnaissance

(This is the third in a series of three articles describing the optical problems affecting earth reconnaissance from a satellite).

By James A. Fusca

Clifton, N. J.—All reconnaissance satellites seeking to gather data on ground installations or earth cloud cover by means of optical image detecting systems will be limited by the three fundamental considerations of earth radiance, atmospheric optics, and optical resolution limits.

This last article of a series describes the problems arising from the physical limits of optical resolution. The series is based on a report on considerations for reconnaissance satellites prepared by the Space Reconnaissance Laboratory of Allen B. Du Mont Laboratories, Clifton, N. J.

The limits on resolution of an optical system are well established by the science of physical optics. Often less well appreciated are the limitations of the human eye in detecting resolvable detail and, since the ultimate use of a reconnaissance picture is for human interpretation, both restrictions on usable resolution must be considered in assessing over-all performance of a reconnaissance system.

The fact that the human eye requires much higher contrast for the detection and recognition of fine detail strongly implies that an optimized visual communication system should include some form of visual pre-emphasis or image enhancement. While such a technique does not affect the resolution limits or bandwidth requirements, it does provide full utilization of the resolution or bandwidth employed.

Diffraction Limit

The ultimate resolution of any objective lens or optical system is limited by diffraction phenomena. This is a fundamental physical limitation that cannot be avoided and that places a very definite limit to the size or spacing of objects that can be viewed at a given distance by a particular objective lens.

Under practical conditions, many objective lenses have insufficient quality for diffraction to prove a limitation. Where the field of view is sufficiently small, however, it is possible to make optical systems that closely approach optical perfection. For this reason an analysis of diffraction effects, which assumes perfect optics, is of interest.

A perfect optical system cannot form a point image of a point object because of diffraction phenomena. Instead, the image takes the form of a bright core and concentric light and dark rings of decreasing intensity, the pattern known as the Airy disk. In the past, astronomers have considered resolving power as the ability to resolve the spacing of two equally bright point sources such as stars, and this problem is treated in any standard optical text.

It has been found that the two points can just be resolved as separate when the bright center of one Airy disk approaches the center of the Airy disk of the other no closer than the first dark ring. This just resolvable distance is equal to the radius of the first dark ring. It can be expressed in angular terms as the minimum resolvable angle (in radians) being equal to a constant (1.22) times the wavelength of radiation divided by the aperture diameter of the objective lens where the wavelength

and aperture are measured in the same units.

When only a single point is resolved, it is customary to give its diffracted size by the angular diameter of the first dark ring. This is justified because about 84% of the total energy in the diffraction pattern appears in the central bright disk. This angle is, of course, twice the angle given by the formula above because the diameter rather than the radius is measured.

The most important point brought out is that the angular size of the diffraction pattern depends only on the diameter of the objective, either reflecting or refracting, and the wavelength of the radiation observed—nothing else.

Neither the relative aperture nor the focal length alone determines the diffraction except as related by the equation stating that the relative aperture is equal to the focal length divided by the aperture diameter.

As a sample calculation, assume that an objective of 200 mm. diameter views a scene radiating light of 0.8 microns wavelength. Then, solving to obtain the minimum resolvable distance in angular terms, the solution is $5^1 \times 10^{-4}$ radian. If the earth were 1,000 mi. away, the minimum point separation would be about 25 ft. on the ground. On the other hand, a very small isolated object would have an apparent diameter of 50 ft.

Aperture Ratio

Note that the same resolution is obtained as long as the wavelength/aperture diameter ratio is held constant; for example, 0.4 micron and 100 mm. or 1.6 micron and 400 mm. The farther the radiation is into the infrared, the poorer the resolution becomes, since the resolving power varies inversely with the wavelength.

In order to specify diffraction limitations in parameters consistent with considering the optical system of a reconnaissance satellite to be one in a communication system, it is simpler to specify the sinewave amplitude response. As can be seen from the equations mentioned above, the sinewave amplitude response of a perfect lens specified as a spatial frequency of separable points or lines at the image plane is dependent only on the relative aperture of the lens. One of the accompanying charts gives this data in sinewaves/mm. units, while a second chart provides this data in a more convenient form by giving the angular sinewave response in sinewave/milliradian units.

For a given focal length lens the amplitude response in sinewaves/mm. frequency can be found from the angular resolution data. For example, assume the case of a 250 mm. f/2.5 objective lens is used with 0.8 micron radiation. This entrance pupil is then 100 mm. and on the chart giving angular sinewave response the 50% amplitude response point is reached at 50 sinewaves/milliradian. Because one milliradian times the 250 mm. focal length gives an image length of 0.25 mm. which contains 50 sinewaves, the result is 200 sinewaves/mm.

Visual Acuity

A commonly accepted figure for the resolution acuity of human vision is one minute of arc for adjacent targets. This refers to small targets having high contrast from the background and adequate brightness. It is also known from the Weber-Fechner law that for large adjacent targets a contrast acuity of a few percent is obtained. Therefore, the classical data on visual acuity holds essentially for small area, high contrast and large area, low contrast conditions.

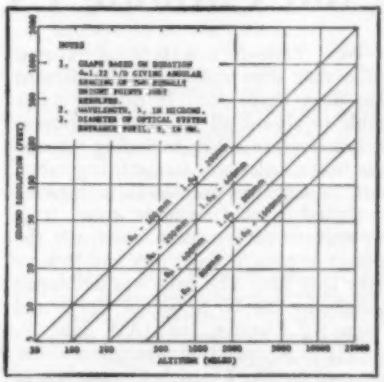
Because of the various image degradations unavoidable in a satellite reconnaissance system, the photo-interpreter on the ground will not be presented with either of the above conditions. Instead, he will be concerned with the detection of small area, low contrast targets.

Another fundamental of visual acuity less well known is Ricco's law. This states that for small targets to be equally detectable, the product of contrast times the solid subtended angle must be constant. It is thus seen that the required constancy of contrast times solid angle is another way of saying that the target energy must exceed the background energy by a fixed amount. Since for small images the human eye responds on the basis of the total light energy received, Ricco's law has a logical physical significance.

In specifying visual acuity in target detection and evaluation systems, it is necessary to know more about the region between the large area data of the Weber-Fechner law and the very small area data of Ricco's law. This information is available from a study by H. R. Blackwell which presents data on small area, low contrast threshold detectability for trained observers. Some of the more important results are:

- **Contrast versus size** detectability curve is constant for background brightness exceeding 10 foot-lamberts.
- **Results hold equally well** for positive or negative contrast.
- **For target subtense** exceeding 100 min. in arc, the threshold contrast is 0.64%.
- **For targets subtending** less than three minutes of arc, equal detectability is obtained when the product of contrast times the solid subtended angle is constant.
- **Detection probability curve** as a function of constrast is independent of size and brightness variables.

The curve for threshold contrast as a function of visual solid angle is given in an accompanying chart. Threshold contrast is defined as that contrast where it is 50% probable that detection will occur, chance detection having been subtracted.



GRAPH showing the diameter of the Airy disk generated by a point source object on the ground versus altitude above the earth for various wavelengths and objective lenses. Airy disk diameter is twice the width of two resolvable points.

Image Enhancement

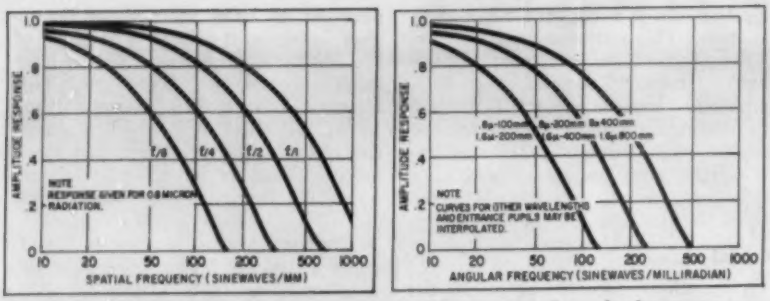
The earlier discussions have shown that one important parameter of the resolution characteristic of any imaging system is the sinewave response. The sinewave response is expressed as a curve giving relative amplitude of the output to the input modulation as a function of its spatial frequency, either sinewaves/mm. or sinewaves/milliradian.

At higher frequencies all optical imaging systems exhibit decreased modulation amplitude response. Unfortunately, visual acuity data also shows that greater not less modulation is required for the detection of small targets.

The cascading of these two problems makes doubly difficult the task of the photo-interpreter.

One approach to correcting these two difficulties is image enhancement. But image enhancement can accomplish much more. Entirely aside from the problems of resolution, another system problem is the great range of contrasts encountered in aerial reconnaissance.

Near the limit of resolution any target will be imaged with a contrast of only a few percent. That is, its imaged brightness will differ by only a few percent from the background. On a clear day, with the sun nearly overhead, the incident illumination on the ground is about 10,000 foot-candles,



GRAPHS showing amplitude response versus spatial frequency and angular frequency.

of which 8,000 is direct sunlight and 2,000 is indirect skylight.

The reflectance of typical terrains ranges from 0.05 for forests to 0.80 for fresh snow. Assume that a photo-interpreter is attempting to detect a dark aircraft flying on a partly cloudy day over forest terrain. The least bright background would be the forest in the shadow of a cloud, or 2,000 x 0.05 equal to 100 foot-lamberts. The brightest background would be a cloud, or 10,000 x 0.80 equal to 8,000 foot-lamberts. Contrast range between these extended backgrounds is 80 x 1.

If the aircraft had been painted perfectly black, its intrinsic contrast would be one. But under even clear day conditions the viewed contrast in the visual region would typically be only 0.5. The apparent brightness of the aircraft over the forest would therefore be 50 foot-lamberts for an optical imaging system suffering no degradation. For detection of this aircraft the imaging system would require a dynamic range of 160 to 1.

Near the limit of resolution or under conditions of moderate haze, the contrast attenuation typically would cause the aircraft brightness to differ by only a few per cent of either of the above background brightness values. Therefore, for small target detection the usable dynamic range, or contrast, should be even greater for a practical system—perhaps 1,000 to 1 or about 10 digital bits. The corresponding allowable signal-to-noise ratio must then be at least 1,000 to 1 or 60 db.

These considerations illustrate the fact that dynamic range limitations are a serious problem in any reconnaissance system. The photographs on p. 62 indicate how image enhancement can be used to alleviate this problem.

Actual aerial reconnaissance photographs are printed on glossy photographic paper capable of a dynamic range of only 32 to 1, corresponding to the limitations of a five-bit digital system. The first of the accompanying pictures not only contains vital information in an area covered by a cloud shadow but has the drab, washed out appearance that is unavoidable in order to display the complete tonal range.

The principle of image enhancement by increasing the small area contrast without increasing the large area contrast is shown in the second picture, where the mid-tone contrast is about four times that of the first and small objects are considerably easier to read. This photograph also shows how image enhancement makes recognizable objects in the shadows.

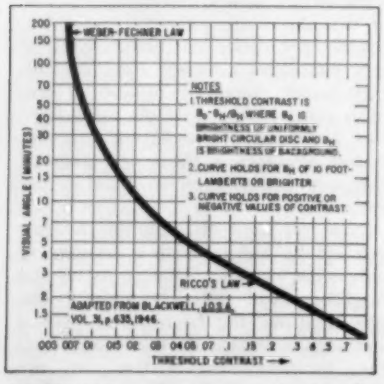
An important fact in these two pictures is that they both have the same limiting resolution and the same contrast range since they both are printed from the same original negative. From a communications standpoint, the unenhanced picture is wasting bandwidth while the image enhanced picture is more fully making use of the available bandwidth. Also to be noted is the fact that image enhancement must be employed before, not after, transmission over a noisy channel.

Image enhancement, basically, is a method of saving transmitter power. Although impossible to illustrate without a transparency print, the detail modulation of the unenhanced picture could be accomplished but only with a dynamic range four times greater or with 16 times greater transmitter power.

In view of the characteristics of the human eye, the interpretable resolution of a satellite reconnaissance system is not uniquely specified by a quantity such as the diffraction-limited angular receiving power of the optical system. Instead, the contrast must also be specified, the two together being most conveniently defined by the system spatial sinewave response.

Thus, the over-all system performance is sensitive to the cascaded effects of object radiance characteristics, atmospheric optics, and the optical and electrical characteristics of the transmitting system through which the reconnaissance picture is relayed.

Video processing at the output of the sensor to obtain proper image enhancement offers important advantages in regard to target recognition. In addition, such video processing will reduce the required transmitter power or, conversely, minimize the effects of relay link noise on the picture for a fixed transmitter power.


WEBER-FECHNER LAW
NOTES
1. THRESHOLD CONTRAST IS
2. CURVE HOLDS FOR
LAMBERTS OR BRIGHTER.
3. CURVE HOLDS FOR POSITIVE OR NEGATIVE VALUES OF CONTRAST.
RICCO'S LAW
ADAPTED FROM BLACKWELL, J.O.S.A., VOL. 36, p. 635, 1946.
VISUAL ANGLE (MINUTES)
THRESHOLD CONTRAST

THRESHOLD contrast versus visual angle.

Cold Cathode Extends Tube Life

New York—A new type of vacuum tube that does not require a filament has been developed. It may be adaptable to almost all the uses of conventional electron tubes, including cathode ray tubes, radar and transmitting tubes, and most general purpose vacuum tubes.

Called a cold cathode tube, it is to operate on less than one-tenth the power of present day tubes and to have very long life. The tube was developed jointly by the U. S. Signal Corps and Tung-Sol Electric, Inc. (AW Jan. 26, p. 35). The operating principle was discovered by Dr. Dietrich Dobieschek of the Signal Corps' Signal Research and Development Laboratory, Fort Monmouth, N. J.

Other types of tubes that do not require a filament to heat the cathode are in common use but these tubes use a gas-filled envelope. The new tube is the first heaterless type capable of operating in many of the applications of general purpose tubes.

Another type of cold cathode tube has been under development since 1955 at Linfield College, McMinnville, Ore., under the direction of Dr. W. P. Dyke. Sponsored by all three services, this type is a high power, cold cathode tube that has delivered up to 20 amp. of current at a peak power of more than one megawatt.

Conventional tubes require a hot cathode element to generate needed electrons. This heating process consumes an appreciable percentage of the power used and forces the use of additional circuitry or extra batteries.

In the cold cathode tube a cylindrical cathode is used that is specially coated

with porous magnesium oxide, chemically identical with milk of magnesia. Instead of heat, a light voltage field causes the electron flow.

The current flow in the cold cathode tube produces a characteristic blue glow, rather than the red glow of an incandescent hot cathode. Once the emission of electrons has been started from the cold cathode—either by a pulse of heat or light, or by nuclear radiation—the reaction can be maintained with as little as 10 microwatts of power. Starting time is less than one second.

The first tube developed is an audio output amplifier capable of putting out slightly less than one watt. Now under development are:

• **Secondary emission** preamplifier. A preamplifier employing secondary emission said to produce more amplification than any commercial hot cathode tube has been produced in sample quantities.

• **Electron gun.** A cold cathode electron gun for use in cathode ray tubes for television, and in klystrons and traveling wave tubes, is under development.

• **Flat display.** A flat, picture-on-the wall type of display device is in the design stage that could be used for television or radar. Possibly, this device could produce greater brightness than is put out by any present picture tubes.

The principle of the cold cathode tube was discovered by accident. While experimenting on field-enhanced secondary emission, Dr. Dobischek noted that one of his experimental tubes kept running after he had turned off the primary current. After investigation, he developed a surface coating capable of emitting electrons indefinitely.

The coating is magnesium oxide which is a phosphor; that is, it emits light when bombarded by electrons. As the electrons strike the atoms of magnesium oxide in their outward passage through the layers, they cause the emission of light which is believed to be the source of the blue luminescence found to be the characteristic of the cold cathode tube.

The advantages of the cold cathode tube compared with the hot cathode type are:

• **Less cathode power** required.

• **Much longer life.** One early tube has been in continuous operation for 14,000 hr. without any decrease in emission.

• **Elimination** of heater failures.

The disadvantages are:

• **Although over-all power** is substantially less, a minimum voltage of about 300 v. is necessary for operation.

• **Present tubes** are not self-starting; a starting means must be provided.

• **More complex** internal structure.

Both types of tubes are about equal with respect to cost and noise level. The processing, however, is sufficiently similar so that the same factory machines may be used for production.

Trailer Van Model 122 for air traffic control, and general surveillance purposes. Model 123 is the same van, less dome.

NEW FROM CRAIG!

Helicopter-Transportable Van!

Here's the first helicopter-transportable van — Craig's new lightweight Model 123. It weighs just 1100 lbs., measures 70" x 58" x 51" inside and packs a 2100 lb. payload.

With unlimited mobility as per MIL-M-8090, it can be towed by ¼, ¾ or 2½ ton vehicles, and features a self-contained hydraulic braking system actuated by the van lunette.

Designed for a wide variety of military applications, this compact, all-weather flying van is completely insulated and water tight. A poured-in-place plastic core, sandwiched between tough, lightweight aluminum skins, provides high strength with minimum weight.

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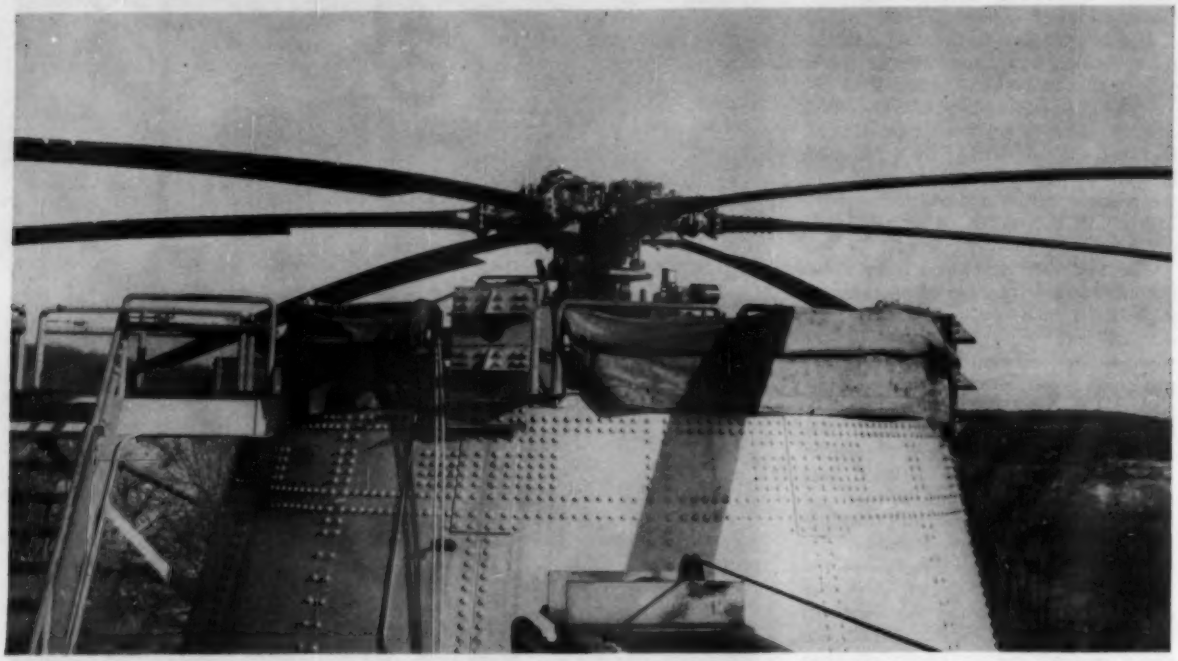


SIKORSKY'S new rotor configuration, with six S-56 blades, soon will be flight tested. Blades are 72 ft. in diameter. Configuration is expected to increase S-56 speed about 30 kt. Company will run 12 blades on test stand later this year.

Sikorsky Broadens Its VTOL Research

By Robert I. Stanfield

Stratford, Conn.—Sikorsky Aircraft, in a major step toward developments, other than the true helicopter, has established a new research group to delve into advanced systems of VTOL (vertical takeoff and landing) flight, in addition to rotary wing improvement. The move reflects increased company interest in all areas of direct-lift aircraft.

Studies now under way—in design status—include a delta-wing, high-speed convertiplane and a compound helicopter with a range of 300 naut. mi.

The company, which has no immediate plans for "changing horses" in light of the efficiency, capabilities, and growth potential of the helicopter "that is only beginning to be tapped . . . the 200 mph. helicopter is capable of attainment," will not dilute its main engineering effort from its present rotorcraft channels, AVIATION WEEK was told.

The new Advanced Configurations Research Section is headed by Philip L. Michel, who is responsible to Michael E. Gluhareff, Sikorsky engineering manager. Along with the equally new Propulsion Research Section, it has been added to the engineering department organization in line with United Aircraft Corp.'s policy of emphasis on basic research and development.

In addition to investigating and analyzing advanced systems of VTOL flight, the group will initiate and carry out research, and maintain liaison with the chief scientist of United Aircraft Corp. (Perry Pratt), keeping him advised of Sikorsky's research efforts and progress.

Design Details

Sikorsky project details currently under study include:

• **Delta-wing convertiplane.** One of the promising configurations embraces a single-blade rotor with counter-balance. Rotor blade would stow at speeds approximating 100 kt. and aircraft would become fixed-wing. Speed, at low altitudes, would be about 500 kt. Jet power, which could be supplied by Pratt & Whitney JT-12s, would be in 5,000-lb. thrust class. Small machine would carry no more than two or three men.

• **Compound helicopter;** a rotor-unloading type aircraft with fixed wing and propellers, not necessarily using autorotation of blades in cruising flight. Sikorsky feels high speeds can be reached by unloading rotor blade and adding extra propeller-type propulsion. Aircraft will not necessarily incorporate a tip-jet propulsion system, the main objection to which is noise and high fuel consumption. Payload would be the equivalent of 40 people with baggage. Range, 300 naut. mi.

• **Rotor configurations.** Company shortly will flight-test six 72-ft. diameter S-56 blades now running on test stand. Configuration is expected to increase S-56 speed about 30 kt. (world record of 162 mph. was set by this helicopter in 1956). Power will still be supplied by two Pratt & Whitney R2800 engines. Sikorsky also is running eight blades on test stand (about one-fourth the size of the S-56 blades) and intends to run 12 blades later this year.

• **Commercial version of S-61** (Navy's HSS-2), on drawing board, would be a seven-blade helicopter powered by three General Electric T58 turbine engines. Aimed at intercity transport, cruise speed would be 150 kt. Range, with 28 passengers, would be 300 naut. mi. Sikorsky is 99% sure that the helicopter will meet performance specifications. Design, the first directed primarily at the commercial market, is an outgrowth rather than an adaptation of the smaller-fuselaged HSS-2, which will fly in March.

• **Turbine-powered flying crane,** capable of 20-ton payload, which can use S-56 blades attached to a disk-covered rotor. The S-60 flying crane, developed entirely with company funds (AW Oct. 13, p. 29) and employing Pratt & Whitney R2800 engines, will make its initial flight in March. Mission profile is 50 naut. mi.; payload will approximate seven tons.

Sikorsky underwrites its own basic research costs, though the convertiplane study was initially funded–a few years ago–through Air Force contract. The company's research budget for 1959 has been increased almost 50% over what it was last year, Lee S. Johnson, general manager, told AVIATION WEEK.

Trouble Shooting

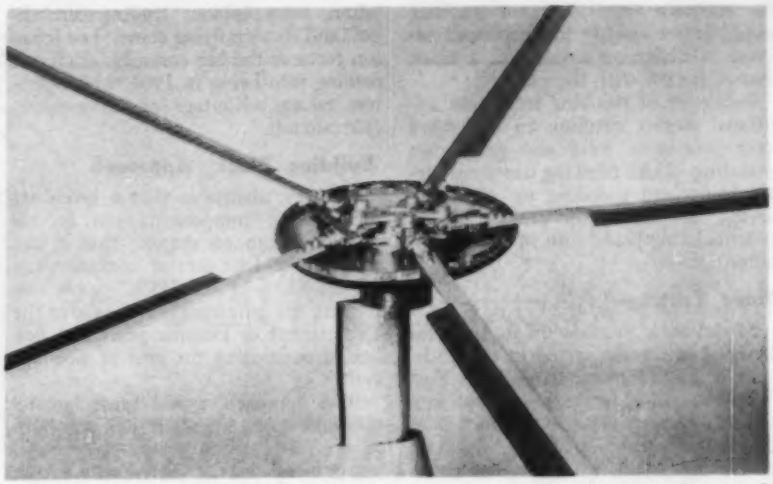
Though the convertiplane can achieve high speeds, Sikorsky sees "nothing exciting in VTOL development as yet," feeling that much work is necessary before aircraft could be commercially or economically adapted. Reason: the current low useful-load/gross-weight percentage; increased horsepower necessary for good hovering characteristics, which presently do not compare with those of the helicopter, and heavy fuel consumption.

The company does feel that the VTOL is adaptable to special military missions, such as high-speed rescue work behind enemy lines, and as a courier or photographic craft. Also under study is the idea of attaching direct-lift aircraft under the belly of a "mother" plane. Sikorsky's convertiplane already has been in two wind tunnels, at USAF's Wright Field and United's East Hartford facility.

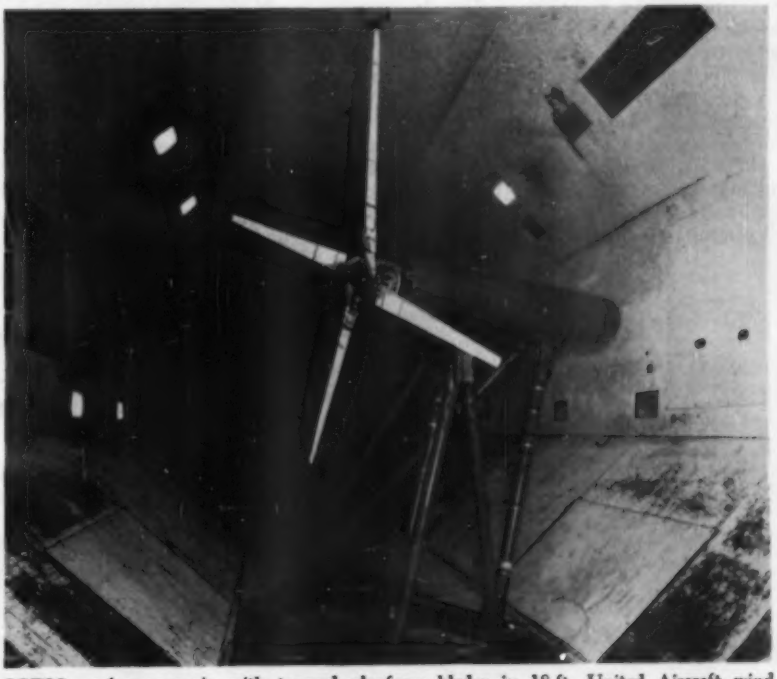
By comparison to present VTOL shortcomings, Gluhareff stressed the advantages of the pure helicopter: low horsepower, good payload, excellent hovering characteristics, and speeds of 150 kt. He feels that "within the 200-300-mi. radius, the helicopter is the only machine which can compete with the bus, truck and railroad . . . no matter how fast fixed-wing aircraft fly between 200-mi. cities, the helicopter is the best bet because of the time consumed between city and airport."

Sikorsky does not expect to come up with a "blast-off vehicle," according to Michel. The company's aims in VTOL development embrace good hovering capabilities, safety in event of power failure and small-area landing characteristics.

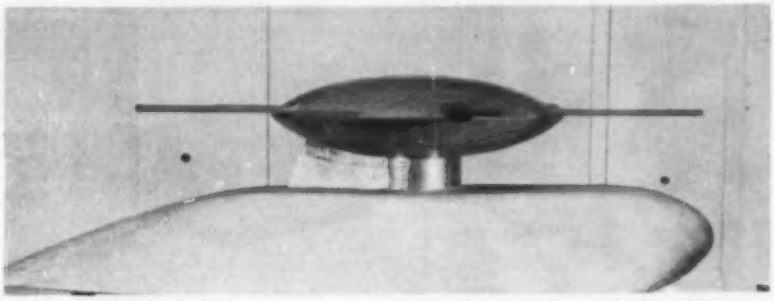
The company foresees a great future in the flying crane, militarily as an all-missile carrier and commercially in the construction field and as a freight carrier also capable of carrying aloft (above weather) and launching a complete airplane. The crane also would be designed to pick up an airplane, in the air, and then land it on a roof in



ONE-EIGHTH scale model of S-56 72-ft. rotor with upper rotor head fairing cover removed. Flapping and lag hinges can be seen. Full-scale blade stresses are duplicated.



ROTOR performance rig with tapered planform blades in 18-ft. United Aircraft wind tunnel in E. Hartford, Conn. Testing will run from 50 to 250 mph. velocities.



BOUNDARY layer control application is aimed at reducing rotor head-pylon (body) interference drag during drag reduction research for high-speed flight.

the midtown area. A major trucking manufacturer already has expressed interest in designing a pod, off a truck chassis, for use with the crane.

Indicative of thinking trends are additional studies covering an integrated rotor (one-piece rotor and gear box), retreating blades (slowing down advancing blade and speeding up retreating blade), and a Uniball project (sealed in articulating blade with lifetime lubrication).

Blade Testing

Model rotor systems up to 10 ft. in diameter are being tested in the 18-ft. United Aircraft wind tunnel in East Hartford, Conn., under conditions simulating 300-kt. velocities. Test blades are dynamically similar to full-scale blades. Stresses can be measured with good results. New performance ideas on rotors can be studied while determining stress limits.

During blade flight tests Sikorsky uses a specially made Fairchild Camera & Instrument Corp. high-speed camera —10,000 frames per second—which sits on the rotor head or blade itself. Pictures of the blade in flight are slow motion.

Looking to the immediate future, Sikorsky says the greatest helicopter achievements incorporate the transition to turbine power, all-weather instrumentation, omniphibious landing capabilities, and its own flying crane. Lee Johnson foresees the big commercial market coming into being in 1961, with operators taking advantage of turbine-powered aircraft.

'Building Block' Approach

Sikorsky maintains that a given set of dynamic components can be exploited as can an engine; that it can take any of four sets of components—S-55, S-58, S-56 and HSS-2—apply and refigure the airframe, and thus save the Department of Defense years and dollars in computing the cost of new aircraft.

The approach would mean greater overhaul and retirement periods, both at the introduction of the new model and throughout its service life. Also, the use of existing spares inventories would reduce the cost of support, and interchangeability of spares between models would simplify the logistic problem.

Sikorsky's S-62, for example, combines the dynamic parts of the S-55, including the main rotor head; the company built its own gearbox. Chief savings in military purchase would be the need for only a few hundred new items rather than several thousand. Biggest immediate savings would be the skipping of purchase of spare components, necessary to new aircraft, in quantities to meet 250-hr. overhaul intervals (AW Aug. 25, p. 64).

The S-62 would embrace 650-700 hr. overhaul components, with service life of rotating components in the 5,000-6,000 hr. range. A new helicopter, according to Sikorsky, would require about 30 months to produce. Initial production version of the S-62 will be available in an 11-month period, or 1.5 years earlier.

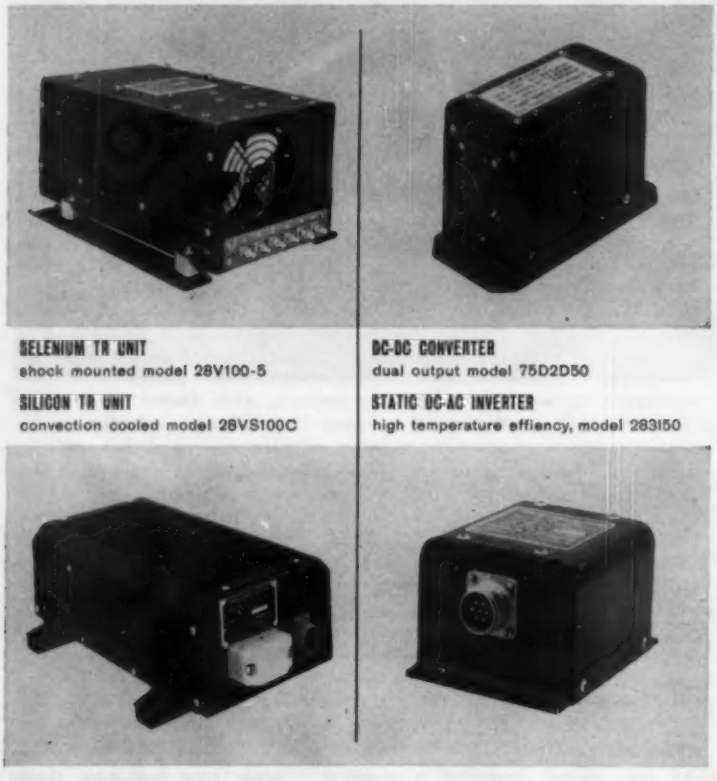
The building-block concept, stressed Johnson, results in an over-all savings of 50% of time, and a savings of half to two-thirds of money.

S-60 as Example

The S-60 flying crane, for instance, will be derived from the S-56 rotor system and mechanical components.

Extending this arrangement further, to cover a turbine-powered S-64 amphibious transport, the present dynamic components will remain and the anticipated extension of overhaul and retirement times will progress at a uniform rate, thus saving about 70% of the cost of a new aircraft in the retrofit (turbine powered) version and about 45% in the optimum Army version.

Main rotor blades already have been developed to a service life beyond 1,000 hr. and the transmission system is substantiated for 5,000 hp., which is more



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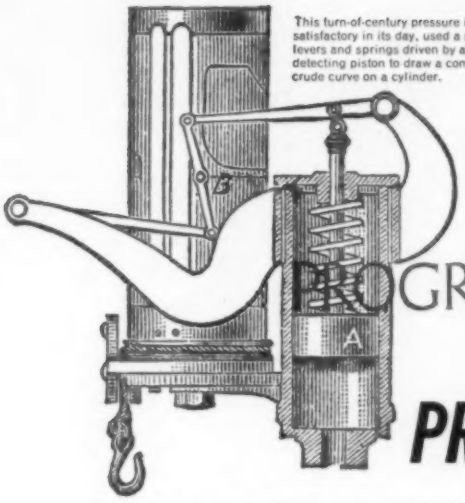

This turn-of-century pressure indicator, satisfactory in its day, used a system of levers and springs driven by a pressure-detecting piston to draw a comparatively crude curve on a cylinder.

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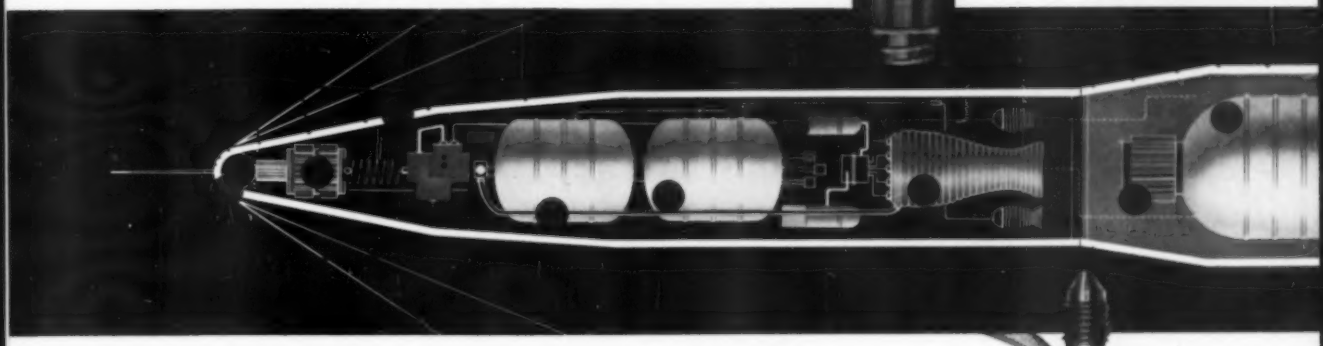

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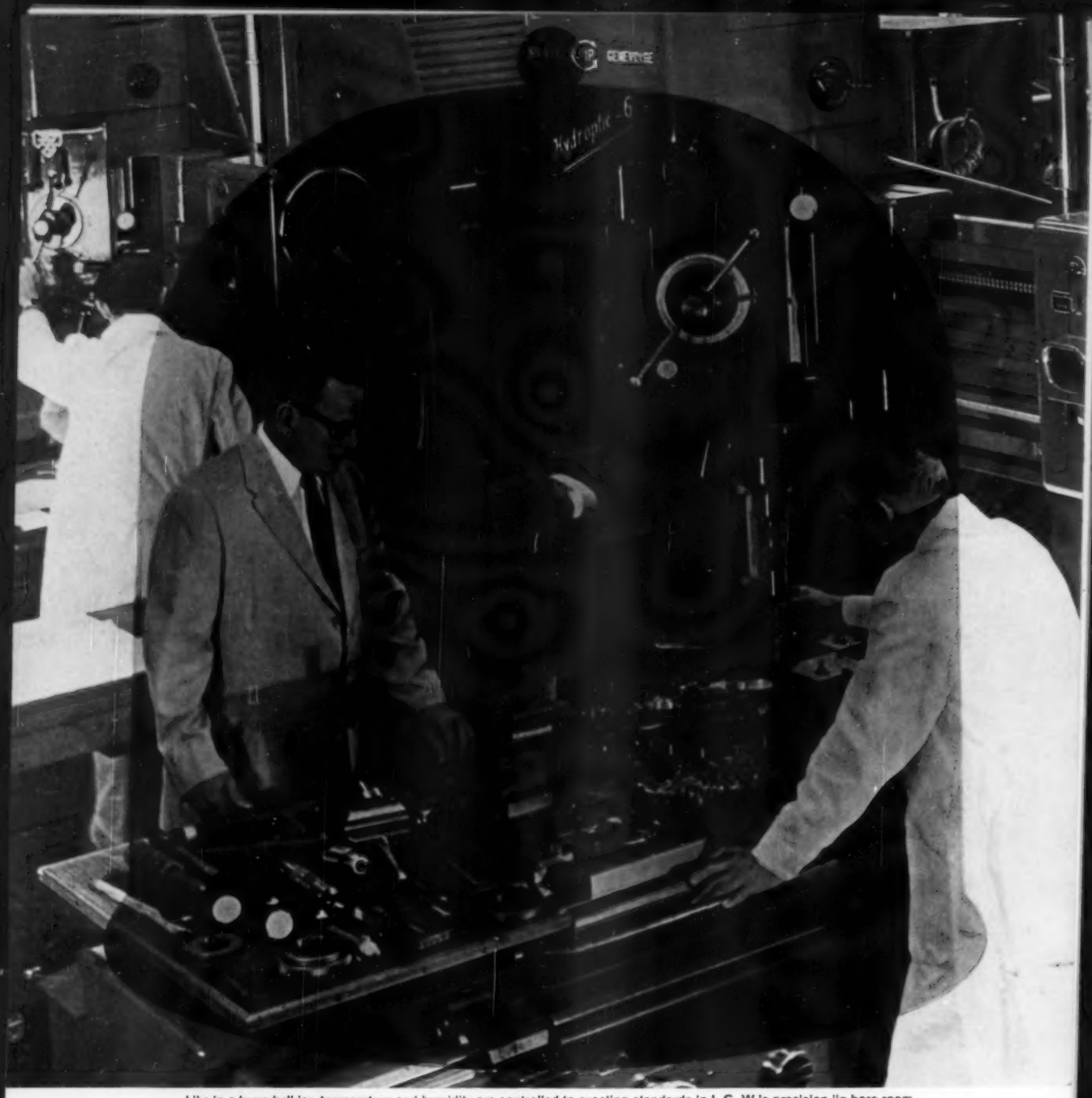

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than adequate for the JT12 engines. Although each engine will be operated in derated condition, the 4,200 hp. available from one engine is sufficient for hovering at normal gross weight with one engine inoperative.

Sikorsky also points out that a newly developed general purpose helicopter having a gross weight of 7,500 lb. and an initial program cost of $150,000 per aircraft has an average terminal life of 1,000 hr. for its repairable mechanical components and an average period between overhauls of 350 hr.

By comparison, a helicopter using existing components has double the average elapsed time between overhauls and double the terminal life for components.

Savings on this helicopter, which uses already developed components of approximately $7.5 million (based on 100 helicopters over the useful life of the aircraft), would be equivalent to one-half the initial procurement cost of the helicopter.

Bell HU-1 Completes Flight Test Program

Ft. Worth—Army has completed a 1,000 hr. flight test program on the Bell HU-1, furnishing experience on the turbine-powered helicopter that normally takes at least three years of ordinary service use to obtain.

Conducted at Ft. Rucker by the Transportation Aircraft Test and Support Activity, the accelerated test program put 1,000 hr. on the Bell machine in five months. Bell said the logistical support evaluation, conducted on a service test version of the HU-1, kept the helicopter in the air an average of 10 to 12 hr. a day, seven days a week.

In commercial operations, Bell sold more than 100 helicopters in 1958. Last year was the second consecutive year that commercial sales topped the 100 unit mark, and Bell has sold more than 800 commercial models since the first machine was certificated in 1946.

WHAT'S NEW

Publications Received:

The Air Forces of the World—by William Green & John Fricker—Pub. Doubleday & Company, Inc., 575 Madison Ave., New York 22, N. Y. $10.95; 336pp.

Book is a comprehensive study of the world's air forces, listing the aircraft types each country uses, along with other numerous facts.

Jane's All The World's Aircraft 1958-1959—Pub. McGraw-Hill Book Co., Inc., Trade Book Department, 330

project:

BUILDING COMMUNICATIONS SYSTEMS AT 60 mph

FRI's Flying Cable Cartridge allows complete network to be laid by helicopter

Previously, communications cable was fed out from uncontrolled reels. However, when the cable hit a snag, the reel fed out too quickly. The cable cascaded, tangled—or broke. Flight Refueling, Inc., in conjunction with ITT Laboratories, designed and manufactured a complete package that feeds the cable out smoothly, evenly . . . and fast . . . no matter how rough the terrain.

This is only one of the many controlled airborne suspension projects from FRI. Others include design study of equipment for towing targets at high speeds, trailing dip sonar systems and fire-fighting packages for transportation into stricken areas by helicopter.

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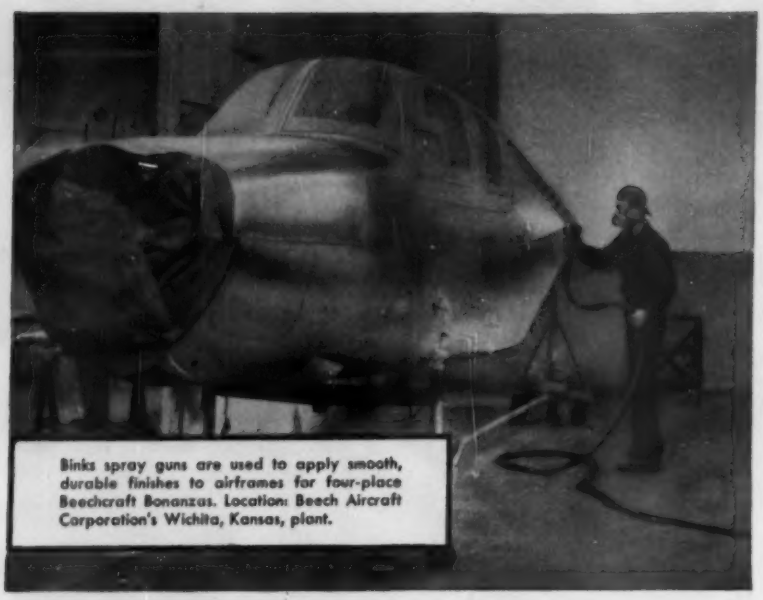

Binks spray guns are used to apply smooth, durable finishes to airframes for four-place Beechcraft Bonanzas. Location: Beech Aircraft Corporation's Wichita, Kansas, plant.

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Binks spray gun dependability keeps finishing on schedule

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West 42nd St., New York 36, N. Y. $30.00; 488pp. plus index.

Book contains information on aircraft, missiles, rockets, gas turbine and piston engines, and helicopters.

Physical Laws and Effects—by C. Frank Hix, Jr. and Robert P. Alley—Pub. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. $7.95; 291pp.

Book presents the description of laws and effects, cross reference by fields of science and cross reference by physical quantities.

Electricity In Aircraft—by F. G. Spreadbury—Pub. The Macmillan Co., 60 Fifth Ave., New York 11, N. Y. $8.00; 342pp.

Survey discusses electrical ignition as an application to turbine starting, and also discusses a.c. versus d.c. currents.

Rocket Propellants—by Francis A. Warren—Pub. Reinhold Publishing Company, 430 Park Ave., New York 22, N. Y. $6.50; 218pp.

Book discusses in detail both solid and liquid propellants used in rockets, propellant burning, ignition and ignitors, and the various rockets that use each kind of fuel.

Electronic Avigation Engineering—by Peter C. Sandretto—Pub. International Telephone and Telegraph Corp., 67 Broad Street, New York 4, N. Y. $9.50; 755 pp.

Book covers radio and electronic aids to aviation, with various systems grouped in four classes based on the operational problems of aircraft.

Fundamentals of Advanced Missiles—by Richard B. Dow—Pub. John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. $11.75; 567 pp.

A summary of the basic principles in control of missiles and space vehicles.

Rocketry and Space Exploration; the International Story—by Andrew G. Haley—Pub. D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J. $6.75; 334 pp.

A history of rocketry, its famous men, and also of its future and production.

A Picture History of Flight—by John W. R. Taylor—Pub. Pitman Publishing Corp., London. $7.50; 192 pp.

A history of mechanical flight with photographs from many countries.

Guided Missile Engineering—edited by Allen E. Puckett and Simon Ramo—Pub. McGraw-Hill Book Co., 330 West 42nd Street, New York, N. Y. $6.50; 497 pp.

This book presents principles and techniques of sciences used in the introduction to guided missiles engineering.

Navy Contracts

Following is a list of unclassified contracts for $25,000 and over as released by U. S. Navy contracting offices:

DEPARTMENT OF THE NAVY, Bureau of Aeronautics, Washington 25, D. C.

Hoffman Laboratories Division, Hoffman Electronics Corp., Los Angeles, 120 man months of field engineering services for aircraft electrical and electronic equipment, NOas 59-4022-s (MA-60-809-59), $140,926.

The Martin Co., Baltimore, model P5M-2 airplanes in a/w detail specification SD-434-2-2, NOas-59-0155 (letter contract) (PD-22-1269-59), $23,279,912.

Telephonics Corp., Huntington, N. Y., radio sets in a/w specification MIL-R-19360 (Aer.) NOas 59-0217-f (PD-31-1675-59), $197,633.

Flight Refueling, Inc., Baltimore, 45 man months of field engineering services for in-flight refueling equipment, NOas 59-4075-s (MA-60-787-59), $68,514.

Missouri Research Laboratories, Inc., St. Louis, model no. 312D range/range rate calibrator (janized), spare parts, etc., in a/w specification MIL-T-945A and amendment no. 2 thereto, NOas 58-884-f (MA-51-3719-59), $555,164.

Loral Electronics Corp., New York, N. Y., 36 man months field engineering services for aircraft electrical and electronic equipment, NOas 59-4045-s (MA-60-811-59), $44,460.

Fairchild Camera and Instrument Corp., Syosset, N. Y., 17 man months of field engineering services for camera installations, NOas 59-4038-s (MA-60-779-59), $25,561.

Allen B. Du Mont Laboratories, Inc., Clifton, N. J., 36 man months of field engineering services for aircraft electrical and electronic equipment, NOas 59-4030-s (MA-60-804-59), $43,550.

Texas Instruments, Inc., Dallas, 36 man months of field engineering services for aircraft electrical and electronic equipment, NOas 59-4024-s (MA-60-820-59), $48,015.

Utica Division, Bendix Aviation Corp., Utica, N. Y., 33 man months of field engineering services for starters, NOas 59-4095-s (MA-60-772-59), $52,956.

Ansul Chemical Co., Marinette, Wis., wheel-mounted fire extinguishers in a/w Ansul Chemical Co. drawing nos. 3482, 3346, 14FP77, 14FP76, 14FP54, 14FP55 and 14FP56, NOas 59-1424-f (SE-72-4032-59), $80,725.

AVIATION SUPPLY OFFICE, 700 Robbins Avenue, Philadelphia, Pa.

Kollsman Instrument Corp., Elmhurst, N. Y., indicators; airspeed and Mach number for various aircraft, N383(17-383)574-46A (IFB-383-368-59), $67,293.

Octagon Process, Inc., Staten Island, N. Y., de-icing-defrosting fluid, N383-57583A (IFB-383-293-59), $67,471.

Hydro-Aire, Inc., Burbank, Calif., valves: hydraulic for A3D-1 and 2 aircraft, N383-57362A (383/214191/59), $28,757.

Specialties, Inc., Syosset, N. Y., transmitters: angle of attack for F2H-3 and 4 aircraft, N383-57417A (JD-383/216126/59), $39,684.

Texas Instruments, Inc., Dallas, indicators and pressure resistors: used on sonar equipment for various aircraft, N383-57094A (383/9504-5/59), $53,417.

Government and Industrial Division, Philco Corp., Philadelphia, Pa., oil sections: for radar equipment on various aircraft, N383-57249A (383/233209/59), $55,331.

Rohm & Haas Co., Philadelphia, Pa., transparent acrylic sheets: heat resistant, N383-57037A IFB-383-398-59), $29,687.

R. E. Darling Co., Inc., Bethesda, Md., hose assemblies: for oxygen system on A4D-1 and 2 aircraft, N383-57471A (JD-383/217066/59), $63,472.

Joyce Electric Co., Williston Park, N. Y., microphone assemblies: for use on aircraft and ground installations, N383-57081A (383/232068/59), $39,604.

Crawford Manufacturing Co., Richmond, Va., life preservers: non-inflatable, vest type, N383(155)56826A (IFB-383-210-59), $167,343.

This flexible gage or absolute-type instrument is a true primary pressure standard that depends only on fundamental measurements of mass, length, and time for its accuracy. As a pneumatic dead-weight piston gage, it offers the advantages of air rather than oil as the pressure medium.

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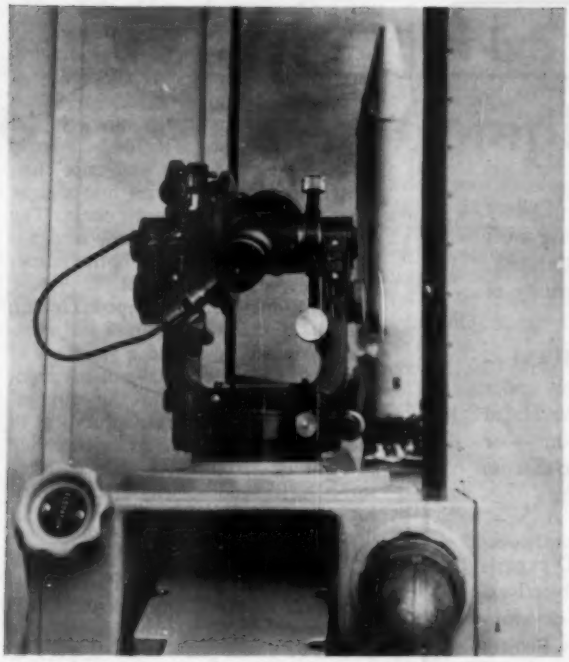

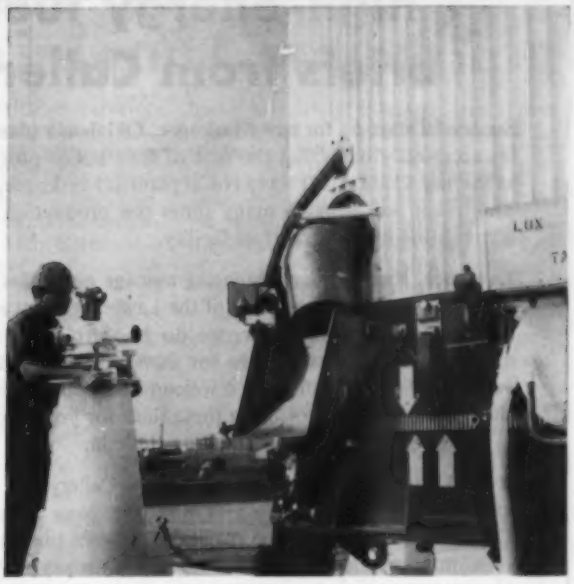

INTERMEDIATE range theodolite (left), positioned 400 ft. from Jupiter missile, aligns stable platform of the missile guidance package. Auxiliary short range theodolite (right) at base of the missile is destroyed by rocket blast when Jupiter is fired.

System Aligns Jupiter Azimuth Heading

By Barry Tully

New York—Aiming or azimuth heading alignment of Jupiter intermediate range ballistic missile is achieved with an optical-electronic system which automatically aligns the stable platform of the inertial guidance system and monitors its alignment until firing.

Optical alignment system of type used with Jupiter is necessary on all inertially guided missiles, including Atlas and Titan intercontinental ballistic missiles and Polaris, Thor IRBMs.

Guidance system for the Jupiter is produced by Ford Instrument Co., Long Island City, N. Y., a division of the Sperry Rand Corp. Perkin-Elmer Corp., Norwalk, Conn., builds the alignment theodolites which are used in conjunction with the guidance system. Perkin-Elmer also builds alignment theodolites for the Thor IRBM.

Direction or azimuth heading that the missile will assume after launching is determined by the physical orientation of the inertially stable platform at the firing instant. The stable platform maintains a space fixed frame of reference during the missile flight. Theodolite alignment system informs missile of target location by assigning desired orientation to reference frame.

Inertial guidance system, if orientated on the correct azimuth heading, will maintain the intended trajectory and, using accelerometers and computers, will solve the cutoff equation for an on-target impact.

Azimuth command given the missile by orientating the stable platform is irrevocable after firing. This irrevocability, while eliminating the possibility of enemy influence through electronic countermeasures, demands the greatest possible precision in aligning the stable platform. Perkin-Elmer points out that 20 sec. of arc error in alignment of a 1,500 mi. range missile will cause an off-target impact of 0.15 mi. The high degree of precision necessary in missile alignment requires the use of theodolites, not only at missile sites, but in the production of stable platforms.

The azimuth alignment theodolite aligns the inertial guidance package with highly accurate directional "bench marks." This is accomplished by monitoring a mirror mounted on the stable platform of the guidance system. Rotational discrepancies in alignment are detected by the instrument which continuously monitors the mirror. Error signals caused by the mirror's rotational discrepancies are applied as corrective signals to the drive elements of the monitored equipment via a closed loop electronic circuit between theodolite and missile guidance package.

The monitoring optical system consists of two modulated light sources, a telephoto lens as the objective, a beam dividing "Vee" prism and a photomultiplier tube.

In operation, the optical system reflects light from a mirror or prism mounted on the stable platform and monitors its return. Two glow discharge lamps are used as sources and are electronically modulated at 400 cps. in phase opposition. The lamps are imaged at the focal plane of the telephoto objective by separate condenser systems. Prism shaped mirror reflects beams along optical axis of objective lens.

If the monitored mirror is perfectly autocollimated with the optical axis of the system, the reflected light will reenter the objective, fall on the opposite side of the prism and will be lost in the source system. Thus, by being perpendicular to the line of sight, a null or "no-signal," will result.

If the monitored mirror is rotated in azimuth even slightly, the returning light beams will not be centered on the optical axis and, depending on the degree of rotation, will pass through a slit (which is ground and polished on the apex of the prism) and strike the photomultiplier. This produces an error signal which, in phase relationship, is representative of the direction and magnitude of azimuth deviation.

Error signals produced by the photomultiplier are fed back to the stable platform to drive it back to conformity with the beam of light (i.e. the correct azimuth heading). The entire closed loop relationship, therefore, is automatically self-correcting, counteracting

high-energy fuel briefs from Callery

Successful start-up for new Muskogee, Oklahoma plant — Callery is successfully operating the first of four major processing units at the new $38,000,000 Navy HiCal plant at Muskogee, Oklahoma. This plant will provide many times the production capacity of any existing high-energy fuel facility.

Lawrence, Kansas plant producing tonnage quantities of HiCal — All of the immediate capacity of the Lawrence plant is now under military contract. However, we do hope to have some HiCal available in the near future for *authorized users*. If you — or your program — qualify, we'd welcome an opportunity to discuss the technical aspects of using these fuels for your project.

Write for new HiCal-3 Handling Bulletin.

R & D on new fuels and propellants? — Callery's R & D experience may prove helpful in attaining your long range objectives. Our current exploration in a number of new phases of development may coincide with one or more of your pet projects. Project teams with up-to-date facilities at their disposal can now be assigned to new programs. We'd like to talk with you about those areas of mutual interest in which Callery is best qualified.

Pyrophoric ramjet fuel: Triethylborane — TEB is spontaneously flammable in air. However, it does not react with water, and this is a distinct handling and operational advantage. TEB — with much wider flammability limits than hydrocarbons — virtually eliminates engine flameouts at high altitudes. Some of the advantages of using TEB as a primary ramjet fuel in place of hydrocarbon-fueled ramjets are: higher altitude operation, increased range, improved fuel economy and reliability, and lower cost vehicles.

Write for Technical Bulletin C-310 and Handling Bulletin C-311.

New 15-minute Triethylborane-Tributylborane fire-fighting film available for loan. Just write 9600 Perry Highway, Pittsburgh 37.

Washington, D. C. office opened by Callery — Fuel and propellant users in the Washington, D. C. area may now avail themselves of technical service at this new Callery office: Room 709, DuPont Circle Building, 1346 Connecticut Avenue, N.W. Phone Richard A. Carpenter, Manager, ADams 4-4200.

Note: Our recently opened office in Dayton, Ohio offers specialized technical assistance on fuels and propellants to interested parties in that area. Contact Anthony C. Hummel at 2600 Far Hills Avenue, phone AXminster 3-2752.

Richard A. Carpenter
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any tendency of the stable platform to drift from the established heading.

The tie-in to the geographical reference or "bench marks" is achieved with a high quality survey theodolite incorporating an accurate azimuth circle and sighting telescope. The desired angle between the sighting or "reference" line of sight and the monitoring line of sight is set off using the azimuth circle. The "zero" setting of the system is determined by autocollimating both systems from a common test mirror.

Monitoring problems imposed by the Jupiter's dimensions, position and guidance system necessitated a variation in equipment from other alignment theodolites and variation in the physical location of the instrument in respect to the monitored axis. The reference line of sight is established with a standard surveying theodolite which is modified for mounting on top to the instrument housing.

Theodolite's electronic unit consists of an amplifier, preamplifier and power supply-modulator. Output signal of the alignment system is either in-phase or 180 deg. out-of-phase with respect to the 115v., 400 cps. reference voltage supply within 10 deg. Maximum output impedance is 500 ohms. Frequency of the output signal is 400 cps. sinusoidal voltage synchronized with the 115v., 400 cps. reference supply. Power requirements are either 60 cps. or 400 cps., 115v., for the 400 watt input power source and 400 cps. 115v. for the 1.0 watt system reference power.

In addition to the primary aiming intermediate range theodolite, the Jupiter uses an auxiliary short range model mounted 3 to 4 ft. from the foot of the missile. The short range theodolite sends beams to an auxiliary prism monitoring unit (with the same heading as the top unit). This monitoring unit is directly connected to the launching ring on which the missile is positioned. A second auxiliary prism also is mounted on the launching ring at an angle representing an alternate target point.

This alternate target prism provides the capability of making a last minute switch to a different target. Another function of the short range theodolite is to provide an all-weather capability by permitting alignment during poor weather conditions which might distort the light beam between the intermediate range theodolite and the missile. The short range theodolite is considered expendable.

Due to its proximity to the missile it is destroyed by rocket blast with each missile firing.

Perkin-Elmer produces a long range theodolite. Model LR1A, presumably for longer missiles. The long range theodolite incorporates a sway compensation system which adjusts for the sway inherent in missiles in the firing position.

Operators Air Complaints on Competition

By Richard Sweeney

San Mateo, Calif.—Protests against helicopter manufacturers competing with the helicopter operating industry in the operators' own field were made at the 11th annual meeting of the Helicopter Assn. of America here.

Speaking for the operating industry, which flies a million hours per year and does about $50 million business annually, was Robert Suggs, president of Petroleum Helicopter Service, Inc., who detailed four areas in which manufacturer-operator relations are strained by manufacturers' practices:

• **Operators face** direct competition from manufacturers in flight operations, in maintenance and overhaul contract competitions. One manufacturer one year made more money in flight operations than manufacturing helicopters, Suggs noted, then asked these questions:

• **Why do manufacturers** overrate their equipment, leaving the operator to try and make good to his customer what the customer has been led to believe the machine can do?

• **Why do manufacturers** introduce new operators on a marginal basis, rather than suppport their best customers, the firmly established operators?

• **Why do manufacturers** try to sell equipment to prospects for the services of the helicopter operators?

Association, composed of operators of helicopters on a for-hire basis, including contract firms and ranging from one-rotorcraft companies to organizations operating more than 50 helicopters, started with 11 members, and now has grown to 80 members.

The operators heard presentations on new applications for rotary wing aircraft, reports on new equipment from manufacturers, plus panels on maintenance, personnel, financing, and associated aspects of the industry.

Flight Demonstrations

Flight demonstrations were conducted during the meeting with Bell, Hiller, Sikorsky, and Vertol helicopters and the two Sud Aviation helicopters, the Alouette II and Djinn for which Republic Aviation is the U.S. sales agent.

Suggs said he has found the general feeling among manufacturers is that the established operator "can be forgotten," while in actuality, these should be the manufacturer's best friends, "if he has any." These established operators offer the best potential sales market, Suggs declared, and the manufacturer will sell more machines in the long run if he backs his steady customer rather than trying to spread his sales base into areas which are, at best, marginal.

One thing which the operators must remember, Suggs pointed out, is that the manufacturers do not really know the operators' problems, and also look at things from an entirely different viewpoint than the operator.

As a solution to part of this, Suggs suggested that forums between operators and manufacturers be conducted several times a year, in which both sides could come equipped with documentation for their stands.

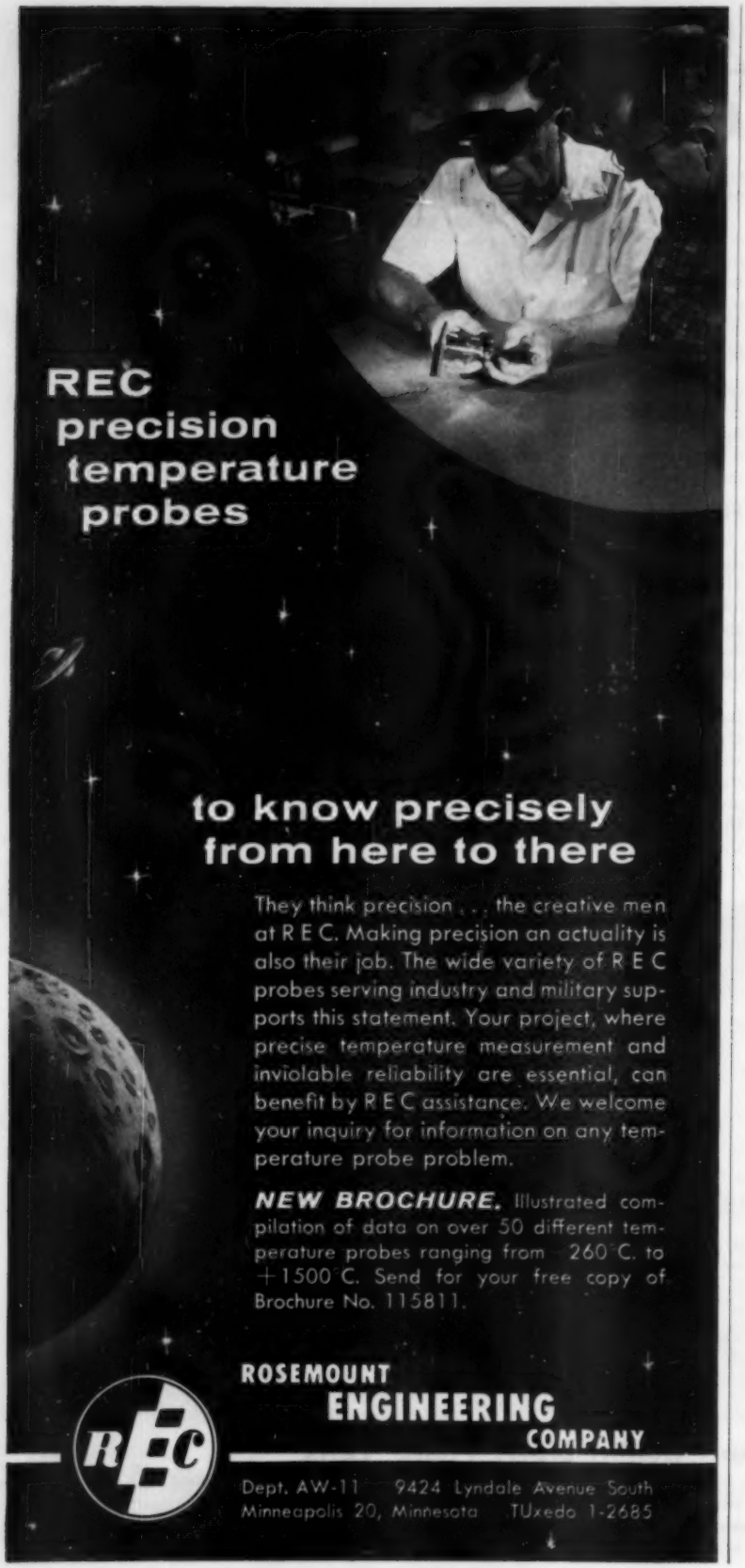
Costs in helicopters could be cut substantially if the military would stress this aspect in its buying, Suggs said. He added that commercial operators cannot get lower prices than the military, yet there is an area here where commercial machines undoubtedly could be produced for less.

Another area in which costs are kept higher than need be for operators, Suggs said, is in the manufacturer not allowing operators to approach vendors directly for parts which are not subject to specification analysis.

One example of this, AVIATION WEEK learned, is in one helicopter pitch change links for the tail rotor. Purchased through the manufacturer, parts

Borgward Kolibri Starts Flight Tests

Borgward Kolibri I (Hummingbird), designed by Prof. Heinrich Focke, has started its flight test program. Configuration shown is the prototype, with uncovered fuselage and considerable test equipment installed. Final configuration will be a three-seater. Novel empennage consists of angled stabilizing surfaces and twin propellers doubling as pitch and yaw controllers, as well as countering the torque of the single main rotor. Powerplant is a single Lycoming VO-435-A1A, rated at 260 hp. (AW Feb. 10, 1958, p. 33).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Helicopter Officers

San Mateo—New officers elected at the 11th annual meeting of the Helicopter Assn. of America annual meeting here are:

President, J. C. (Cully) Weadock, Chesapeake and Potomac Airways, Baltimore; first vice president, Alfred Stringer, Okanagan Helicopters, Vancouver, B. C.; second vice- president, Bill Cowan, Southwest Helicopters, Van Nuys, Calif.; secretary, Hal Conners, Helicopter Air Lift, Chicago; treasurer, Gil Ervin, Hawk Helicopters, Ft. Worth, Tex.

Outgoing president is Richard (Rick) Eccles of Calicopters, Stockton, Calif.

cost $17.88 per set, while from the vendor, cost would be about 50 cents or a dollar, according to an informed source. There are numerous other areas where similar savings could accrue to the operators, AVIATION WEEK was told.

In the competition for maintenance and overhaul contracts, Suggs claimed that the manufacturers bid against the operators, and almost always win due to their factory facilities and other advantages.

In the practicing of dry leasing to operators who cannot afford to buy a helicopter, manufacturers are actually destroying the purchasing power of their best customers, the established operators with substantial investments, Suggs declared.

Manufacturers' constant effort to broaden the sales base, Suggs indicated, can be seen in the belief it is better to sell 1,000 new machines to 1,000 new buyers rather than sell 1,000 machines to one of the regular customers, an established operator.

If the manufacturers will help established operators keep their equipment busy, they will sell more machines in the long run, Suggs declared, rather

Hiller Plans

San Mateo—Hiller Aircraft Corp. intends, within two or three years, to have its annual business on a 50-50 basis between military and commercial sales, Stanley Hiller, president, told the Helicopter Association of America here.

Hiller now is producing more than 100 machines per year, mostly for the Army, and in the next two years, production already contracted for with the military will run to about 150 machines annually. Currently, Hiller business is about 80% military and 20% commercial. Hiller said the company is pinning its hopes on its new 12E model, with 305 hp. Lycoming engine, to close the gap between military and commercial sales.

than constantly trying to compete with the operators.

In new applications, U. S. Forest Service work was described in which Sidewinder missile is being studied for fire applications. Describing the new application was Cal Ferris, Director of Aviation for Region IV.

Since Sidewinder infrared guidance seeks the hottest source to home on, the missile could be loaded with special chemicals instead of explosive, to fight the heart of petroleum and industrial fires. Method of employment would be to fire the missile from a platform suspended underneath a helicopter. Exact chemical which would be used now is under study, Ferris stated.

In California last year, Ferris pointed out, some 2,500 hr. of helicopter time were contracted by the Forest Service, providing some $250,000 in annual business.

Additionally, 11,400 small helistops for landing men, and equipment to quickly put out fires before they get well started have been built, and eventually will number 14,000 in forest areas.

Clinton Phillips and Herbert Shields of the Forest Service also detailed work being done in development of equipment tailored to light helicopter transportation to fire areas, aimed especially at reaching fires within minutes of when they start and putting them out before they become major conflagrations.

Applications in geological and petroleum fields also were outlined at the meeting, with large, tandem rotor Vertol helicopters taking over the task of seismographic team transport in swampy areas, including the equipment required for taking the profiles. Capabilities of large helicopters can be greatly exploited the meeting was told, both in single and multi-rotor and single and multi-engine configurations.

Speaking on prospects for commercial helicopters, L. Welch Pogue of the Helicopter Council of the Aircraft Industries Assn. told the operators that while there are many things in their favor, there are many areas in which they contribute to their own progress.

Areas which he cited included:

- **Public acceptance,** with the operator cooperating to keep annoyances at a minimum while constantly endeavoring to tell his story when and where possible as to the benefits his helicopters can contribute to the community.
- **By keeping posted** on proposed regulations in flight operations, safety and similar aspects of the industry as they are formed by Federal Aviation Agency, and making known their feelings concerning the proposals.
- **By helping communities** plan accurately for helicopters—in heliports, helistops, land use ordinances and other local rulings which, if properly formulated, will smooth the way in the future and not require local battles to get rules changed, a difficult process at best, Pogue indicated.

Another factor which will greatly influence the helicopter industry, Pogue pointed out, is the introduction of turbine power, which will have a great effect on economics of the rotorcraft operating industry; and can substantially cut costs and enable the operator to sell his services to more people for less money, a sure pattern for substantial growth over the years.

PRIVATE LINES

Frederick B. Ayer & Associates, N. Y., reports that of 10 Convair 240s delivered to it thus far by American Airlines it has sold three, two to Southeast Air Lines and one to a U. S. corporation for executive use, and has two on lease to corporations and two on option.

Madison Municipal Airport, Wis., notes that traffic at the field last year totaled 123,146 aircraft takeoffs, an increase of 10% over 1957. Military landings or takeoffs totaled 65,845 or about 53.5% of the 1958 total. Local and itinerant private aircraft accounted for 37,626 landings and takeoffs last year, an increase of 20.74%. Airline operations totaled 19,675, an increase of 8.31%. Airline passengers handled at field by Northwest Orient and North Central airlines last year totaled 124,401.

Pacific Airmotive Corp., Burbank, Calif., purchased Lear, Inc.'s stock holdings of 70,000 shares in PAC, exercising an option. Transaction involved some $250,000 in cash. Stock was issued to Lear, Inc., when PAC took over Lear's Aircraft Engineering Division in 1956, which is now operated as PacAero Engineering Corp.

Cessna YH-41 helicopter completed high-altitude performance tests for U. S. Army in Sierra Nevada mountains, where there are sites at 4,000, 7,000 and 9,500 ft. YH-41 operated from highest site at normal maximum gross weight and with 200-lb. overload.

New Piper distributor for Oklahoma is Ross Aviation, Inc., Tulsa, which will operate its franchise from Riverside Airport. Ross will build additional facilities at the airport.

Titanine has developed fluorescent-type aircraft finishes, trade-named Glare, to specifications MIL-P-21563 (Aer) and MIL-P-21600 (Aer) and reports that samples are available from its Union, N. J., office.

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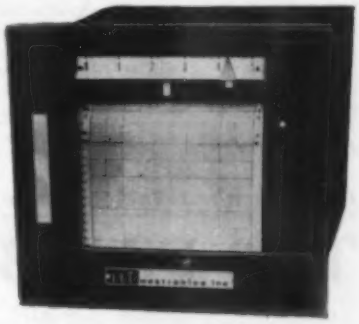

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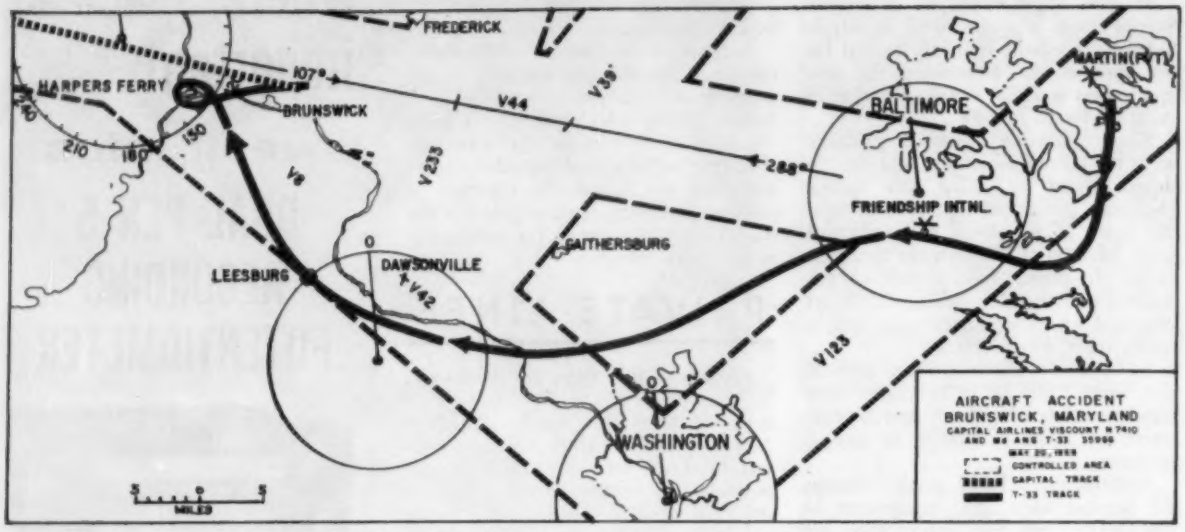


FLIGHT paths of T-33 jet trainer and Capital Airlines Viscount. Collision occurred after T-33 circled Harper's Ferry.

CAB Accident Investigation Report:

T-33 Pilot Blamed in Viscount Collision

On May 20, 1958, about 1129[1] EDT, a Capital Airlines Viscount, N 7410, and a Maryland Air National Guard T-33, 35966, collided in the air about four miles east-northeast of Brunswick, Md. Seven passengers and the crew of four aboard the Viscount were killed. A passenger in the T-33 was killed but the pilot, although severely burned, parachuted safely. Both aircraft were totally destroyed by in-flight collision, ground impact, and the ensuing fire.

The collision occurred at an altitude of about 8,000 ft. on Victor Airway 44 while the Viscount was descending en route from Pittsburgh to Baltimore-Friendship Airport. It was operating on an instrument flight rules flight plan but in visual flight rules weather conditions. The T-33 pilot was on a VFR proficiency flight from Martin Airport, Baltimore, Md.

Just before the collision the aircraft were observed in the area west of Brunswick flying parallel easterly courses with the T-33 some distance behind and to the left of the Viscount. The T-33 quickly overtook the Viscount and made a gentle right turn, during which it struck the forward left side of the fuselage of the Viscount.

Both aircraft were being operated in visual flight rules weather conditions and it was therefore the responsibility of each crew to provide separation from other aircraft by visual reference. The right-of-way rules contained in the Civil Air Regulations clearly set out the pilot's responsibility in the overtaking situation.[2]

It is the Board's aim to provide for a positive control system of aircraft separation which will not depend upon the "see and be seen" principle to prevent the occurrence of collision accidents. The Board has been actively engaged for some time in the development of such a program. Its full implementation is several years away and will be dependent on additional technical improvements in equipment and on the expansion of the air traffic control facilities to accommodate the ever increasing amount of traffic.

Since the accident the USAF and Capital Airlines, along with other carriers, in an effort to reduce collision hazards, have required, in general, that all aircraft on airways above 10,000 ft. be operated in accordance with IFR.

INVESTIGATION

Capital Airlines (CAP) Flight 300 is a regular flight from Chicago, Ill., to Baltimore, Md., with one en route stop at Pittsburgh, Pa. The flight of May 20 departed Chicago at 0755 CDT and proceeded to Pittsburgh. The crew consisted of Capt. K. J. Brady, First Officer P. F. Meyer, and Stewardesses J. Hunt and H. Irrizzary. The aircraft did not require service or maintenance at Pittsburgh. It was properly loaded and dispatched and at 1050 took off for Baltimore. An IFR flight plan had been filed and clearance obtained to cruise at 11,000 ft. to Millsboro intersection, thence to Baltimore via Victor Airways 92 and 44.

At 1115, when crossing Grantsville intersection on course, the flight contacted Washington Center (Washington Air Route Traffic Control) reporting its position and estimating Martinsburg at 1127. Washington Center acknowledged this call and recorded the report on the flight progress strip. At approximately 1124, Center cleared the flight to the Lisbon intersection to descend to and maintain 7,000 ft. At 1126, Capital 300 reported over Martinsburg, leaving 10,000 ft., estimating Baltimore at 1139. When this report was received, Center was able to establish identification of the flight by radar.

Recordings of the conversation between Center and Flight 300 were analyzed. From these it was determined that approximately 41 sec. after the flight reported over Martinsburg it was given a further clearance by the Center controller to descend to cross Sugar Loaf intersection at 5,000 and to maintain 5,000. CAP 300 acknowledged this clearance and reported leaving 9,000 ft. This transmission was made approximately 48 sec. past 1126 and was the last transmission from the flight.

The Washington Center controller who was controlling CAP 300 stated that at the time the target was first identified on the radarscope, Flight 300 was on V-44 proceeding eastward and there was no other traffic noted within 15 mi. of it. In addition, no other target was seen in the vicinity of Flight 300 at the time of the final radio contact. He said that a few minutes after the final transmission, on one sweep of the antenna he saw a faint return of a target near CAP 300. On the next sweep the target had disappeared and the "blip" which was known to have been the Viscount was somewhat enlarged. The controller initiated a call to the flight to determine its altitude and to advise of possible VFR traffic but was unable to contact Flight 300. The target of Capital 300 remained almost stationary on the scope for about a minute and then faded. It was determined that this call was made three minutes and three seconds after Flight 300 had made its report over Martinsburg.

Capt. J. R. McCoy of the Maryland Air

[1] All times herein are Eastern Daylight based on the 24-hr. clock unless otherwise noted.

[2] Civil Air Regulations Part 60.14.

National Guard (Md. ANG) had arrived at Martin Airport several hours before his flight. He had planned several days prior to this to take a member of the National Guard in a T-33 jet aircraft on a familiarization flight in the local flying area.

When the passenger arrived at the field, Capt. McCoy began preparations for the flight. He said he briefed the passenger on use of the personal equipment, oxygen, radio and interphone, and emergency procedures. He filed a local VFR clearance (AF Form 113) and obtained a weather briefing from the U. S. Weather Bureau facility at Baltimore-Friendship Airport by telephone. Capt. McCoy said he then proceeded to the aircraft and conducted a "walk-around" inspection. After satisfying himself that the aircraft was in good condition, he gave his passenger a last check and entered the cockpit to begin the flight.

ANG 35966 took off from runway 14 at 1107. The flight proceeded southward, climbing to 3,000 ft. Capt. McCoy said the weather briefing he had received before takeoff indicated there would be an overcast at 5,500 ft. in the Baltimore area. He said that to his best recollection this was the condition he found. He continued south to about Gibson Island, Md., on Chesapeake Bay, keeping below the overcast, and then turned to a westerly heading, passing north of Washington and south of Friendship Airport to Leesburg, Va.

Capt. McCoy could not recall his various altitudes, headings, or speeds because he was not flying a constant course. He said it was not uncommon for these to vary considerably on a VFR flight. He said the clouds in the Washington area were about 10,000 ft. and that he had at one time climbed to about 9,000 ft. between Washington and Leesburg. From Leesburg, he proceeded up the Potomac River to Harper's Ferry, W. Va. He remembered descending from 8,000 to 5,000 ft. just prior to reaching Harper's Ferry to allow his passenger to photograph this scenic spot. He also remembered that he had selected 85% rpm, but could not recall his airspeed. He said he made a left turn around Harper's Ferry at 5,000 ft. and picked up an easterly heading, intending to proceed to Baltimore via the Frederick, Md., area.

According to Capt. McCoy, after straightening out on this course, he began a slow climb, still maintaining 85% rpm. He did not know his airspeed or rate of climb but did recall seeing the altimeter indicating 8,000 ft. At this point he said, he thought the aircraft exploded. He did not know how he got clear of the aircraft, which was tumbling and afire, but recalled opening his parachute and descending to the ground. He then walked some distance to a farmhouse and requested to be taken to a hospital. There Capt. McCoy learned for the first time his aircraft had been involved in a collision.

Weather Improves

Capt. McCoy, in answer to various questions, said the weather conditions he had encountered had improved as he proceeded west. Near Washington, D. C., the base of the overcast was approximately 10,000 ft. In the accident area there was less than 2/10 cloud coverage and he had remained below these scattered clouds. He said the flight had been a normal VFR proficiency flight and he had not made use of any radio navigation aids, although he was at all times guarding the UHF radio frequency 236.6 mc. (Martin Tower). He also said the airplane had performed satisfactorily and no mechanical difficulty was encountered.

Capt. McCoy further testified that he did not perform any aerobatics nor did his passenger handle the controls of the aircraft at any time. He stated that he maintained a constant lookout for other aircraft throughout his flight. He further said the windshield and canopy of the T-33 were clean and that no distraction or cockpit duties had interfered with his lookout prior to the accident.

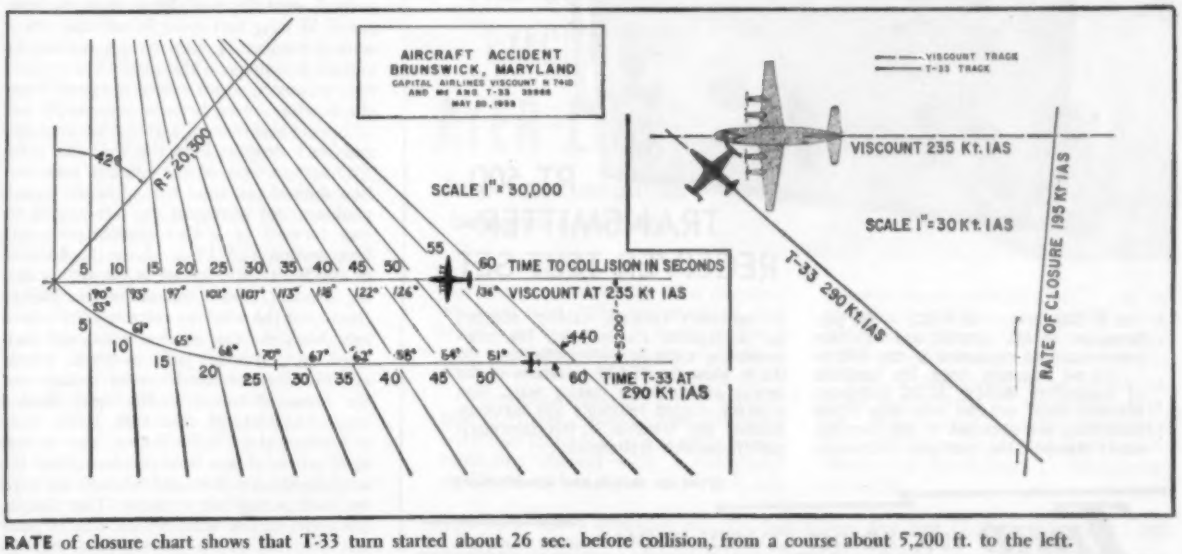
Numerous witnesses in the area were contacted, all of whom were in substantial agreement in their descriptions of the accident. They agreed that just before collision both aircraft were on approximately parallel easterly headings and did not appear to be climbing or descending. Most described the Viscount as flying straight and level and stated that it was ahead of the T-33 at all times until collision. The T-33 appeared to be traveling considerably faster and rapidly overtaking the Viscount from a position behind and to the left. The T-33 was then seen to make a shallow turn to its right during which it struck the forward part of the Viscount. The witnesses said there appeared to be a small explosion when the aircraft hit.

After collision the aircraft separated and the T-33 continued on its original course for a short distance, then exploded. The Viscount appeared to pull up to a near stall, then spin steeply. This spin gradually lessened to a slow flat spin which continued until the Viscount hit the ground. These witnesses, as near as could be determined, placed the collision over a point approximately 14 mi. east of the Martinsburg omni station and one mile south of its 107-deg. radial.

Most of these witnesses viewed the aircraft while looking toward the north. They said they watched as both aircraft passed in front of them from left to right. All of them were able to distinguish the difference between the Viscount and the T-33. These witnesses said that there were light fluffy clouds in the area with the amount of coverage variously estimated from $\frac{1}{10}$th to $\frac{4}{10}$th of the sky. Several witnesses said the jet was momentarily obscured by clouds and thought it either entered clouds or passed behind them; others said both aircraft were below the clouds.

The surface weather chart for 1100 EDT on May 20, 1958, showed a cold front off the east coast extending from Nova Scotia to Norfolk, Va., and thence in a southwesterly direction through the Carolinas and Georgia. A deep low pressure area was centered over Hudson Bay with a ridge of high pressure over central United States.

Surface weather observation at Frederick, Md., at 1056 EDT indicated there was a ceiling of broken clouds ($\frac{7}{10}$ths coverage) estimated to be 12,000 ft. high with visibility 15 mi. It also indicated there was a lower layer of cumulus clouds with bases at 5,000 ft. This lower layer amounted to less than $\frac{1}{10}$th coverage. The 1157 EDT observation showed there were scattered



RATE of closure chart shows that T-33 turn started about 26 sec. before collision, from a course about 5,200 ft. to the left.

clouds at 4,500 ft. which amounted to a ⅞th sky coverage; an estimated broken ceiling at 12,000 ft. of approximately ⅞ths cloud coverage; and a visibility of 15 mi.

Other reporting stations west of the accident site showed similar conditions. The 1000 Hagerstown, Md., observation was high broken clouds, visibility more than 15 mi. The 1100 observation reported scattered clouds at 5,000 and a layer of higher scattered clouds. At Martinsburg, W. Va., the 1000 observation was 3,500 ft. scattered, ceiling estimated 6,500 ft. broken clouds; visibility 12 mi. At 1100 the observation was 4,500 ft. scattered, high thin scattered; visibility 12 mi.

Cloud Cover

The cold front was moving eastward off the East Coast. As shown by the observations, the cloudiness in the Brunswick, Md., area had been decreasing throughout the morning. At the public hearing a forecaster for the U. S. Weather Bureau testified that the weather reports around the area of the accident indicated there were approximately ⅜ths to ⅝ths clouds in the lower levels with bases around 3,500 to 4,000 ft. The witness stated, however, that because of the clearing situation which existed, cloud coverage could vary considerably in a few minutes. It would have been entirely possible for the coverage at a particular time in the area to have been as little as ⅛th to ⅜th.

The wreckage of both aircraft was widely scattered over an area of about one mile by 1½ mi. approximately four miles northeast by east of Brunswick. Although pieces of wreckage from both aircraft were intermingled over the entire area, there were concentrations along separate paths on the ground. Pieces of the fuselage forward of the wing of the Viscount were strewn along a path about 4,500 ft. long, running roughly west to east. The remainder of the aircraft came to rest about 1,300 ft. south of this line of wreckage. It hit in a nearly level attitude on a heading of 65 deg. with little horizontal speed. Impressions and furrows in the ground indicate the aircraft was in a flat spin to the right at ground impact.

Various pieces of the T-33 fell along a line about 7,500 ft. long which diverged southeastward from the Viscount wreckage path. The wreckage path of the T-33 was on a bearing of approximately 155 deg. with the more dense portions of wreckage coming to rest in more southerly positions. The main portion of the Viscount broke up and burned when it hit the ground.

All four engines and propeller assemblies remained in their approximate proper positions. The No. 1 and 2 propellers showed no evidence of inflight impact damage. However, the blades of No. 3 and 4 propellers were severely nicked and scratched by inflight contact with metal objects. The fuselage from station 414 aft was severely damaged by ground impact but showed no evidence of inflight impact. The tail assembly was detached from the fuselage and bore evidence of having struck considerable debris which had scraped and dented it in numerous places.

The Viscount fuselage from station 0 to station 132 was demolished. The lower portion, from the cockpit floor to the bottom of the fuselage, was the largest section remaining. All flight deck installations had been torn off the floor and the top surface of the floor was burned. Some torn edges of aircraft skin remained above the floorline, the inside surfaces of which were burned. Between stations 72 and 102 skin on the left side was torn and curled inward along a fairly straight line extending aft and downward to the floor level. Aft of station 47 the skin above the floor level on the right side of the fuselage was torn away by loads acting left to right.

Floor Crushed

The floor structure was crushed from the left to the midpoint of the fuselage between stations 92 and 112. To the rear of this point between stations 112 and 132 the floor structure, transverse beams, and lower bulkheads were severely damaged and crushed from left to right to the middle of the aircraft.

The nose gear was found in this portion of the aircraft and was in the fully retracted position. The retract strut and its supporting structure, which attaches to the forward side of the bulkhead at station 132, was torn out and the left end of the support structure was deformed to the right by loads acting from left to right.

The left nose gear pivot support, which was torn loose from the bulkhead at station 132, contains a fitting plate with 10 nuts in two parallel rows. These nuts and the bolt-thread ends had deposits of aluminum from the nose section of the right T-33 tip tank. A portion of the station 132 bulkhead angle located about 20 in. below the floorline was bowed inward and upward by impact. The rivet pattern on a piece of skin in this area also matched rivet imprints on the right side of the nose section of the T-33 right tip tank. Three pieces of skin from the left nose section just forward of station 132 near the floorline bore significant inflight impact markings.

The entire outside of one piece which extended from the floorline to the first stringer below and approximately 1½ ft. forward from station 132 was covered with vertical scratches and black deposits from the T-33 wing fuel cells. In addition, there were a number of deep gouges running in various directions on this piece. The remaining two pieces, which extended upward from the floorline 17 in. between stations 90 and 132, were also covered with similar scratches and black deposits from the T-33 fuel cells.

Other portions of the fuselage nose section showed the same type of heavy impact markings and tearing of the left side in an area forward of a line extending roughly from station 122, 17 in. above the floorline to the front lower corner of the pilot's sliding window. Above and aft of this line to the top of the windows there was little damage; however, the window glass was shattered and, although still in place, bowed inward. The windshields were broken and the frames distorted to the right. Several small fragments of nose skin, which were still attached to these frames, and several small pieces of skin from just forward of the windshield were torn and severely distorted by loads acting left to right. The glass in the copilot's side windows was still in place but shattered and bowed outward. No sig-

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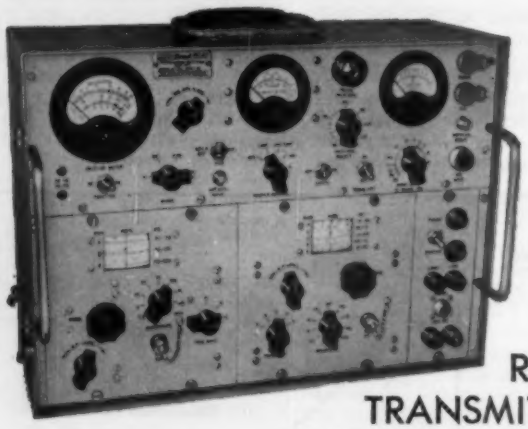

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nicant pattern of scratches was found on the outside of any of the skin from the right side of the fuselage.

The skin on the top of the fuselage from the windshield aft to station 132 was severely battered and torn. In the area to the left of the fuselage centerline there were numerous scraps and gouges running from left to right and slightly forward. In addition, there were several red and blue paint smears in this area. The alcohol deicer tank, which is located in the ceiling of the fuselage left of the centerline and forward of station 132, had a deposit of blue paint on its left end. This end was also damaged by inflight impact. The rams horn antenna was broken from its position on top of the fuselage at station 132 and showed numerous red and blue paint markings on its left side. The antenna matched an imprint on the right side of the aft fuselage of the T-33 at the USAF roundel.

Most of what was found of the remainder of the forward fuselage, aft of station 132 to station 414, had little evidence of flight collision damage. There were, however, four areas in this section which did bear heavy impact markings. One was below the front entrance door on the left side. The skin in the area between stations 132 and 222 and stringers 54 to 59 were missing, but that remaining around the edges of this hole was crushed inward. There were black deposits from the T-33 wing tank fuel cells above this same area from stringer 60 to 62. In addition, a double row of brazier head rivets through stringer 60 below the main entrance door had deposits of green anti-glare paint from the inboard surface of the T-33 right wing tip tank. Several fragments of skin from just forward of the door and between stringers 59 and 60 also had some deposits of green paint. Between stations 168 and 187 the green paint deposits were found just above the double row of rivets at stringer 60.

Paint Marks

Other small fragments of skin from this general area also bore evidence on their outside surface of the green paint from the T-33 tip tank. Scratches on the skin between stations 154 and 176 extended to a line between stringers 54 and 55. None of the green paint deposits were found in these scratches and they appeared to define the lower limit of the tip tank contact with the Viscount fuselage. Rearward the damage inflicted by the tip tank extended to the ice striker plate. On this plate, between stringers 56 and 57, and about station 232, there was an indentation of some 10 in. in length which matched the tip of the fin from the T-33 right tip tank.

Another area of inflight impact damage was on the upper left side of the Viscount fuselage from stations 198 to 232 and between stringers 5 and 10. In this entire area the skin was torn, buckled, and curled by an object moving from left to right, with the most severe damage in an area bounded by station 215 to 232 and stringers 8 and 9. While no precise matching of this damage with the T-33 was possible, it appeared to have been made by the T-33 right horizontal stabilizer, the mangled tip of which was marked with blue and white paint similar to the paint on the Viscount fuselage in this area.

The forward cargo door located on the right side of the Viscount fuselage also showed inflight impact damage. A portion of the main bulkhead on the T-33 right tip tank had penetrated the door between stringers 57 and 58 just forward of station 176. The skin was curled outward indicating movement from left to right and a portion of the bulkhead remained lodged in the hole.

There were deposits of red paint from the tip of one of the Viscount propeller blades on the exterior surface of the Viscount right-hand ice striker plate. The plate was also cut and damaged by this inflight contact.

From the widely scattered wreckage of the T-33 it was evident the aircraft disintegrated in the air following the collision. The fuselage forward of station 228.3 came to rest inverted and burned. No evidence was found in this portion of wreckage to indicate heavy or consistent inflight impact loading. Most of the damage appeared to have resulted at ground impact with the exception of the canopy glass which was found in widely scattered locations and apparently shattered in flight. Portions of this canopy glass and other parts not in the area of ground fire showed evidence of burning or heavy deposits of soot.

The middle section of the fuselage was broken in numerous pieces. One section extending about two feet aft of the rear wing spar, was not severely deformed except for a small puncture in the center of the piece. Aft of this area the right-hand side of the fuselage was severely deformed and

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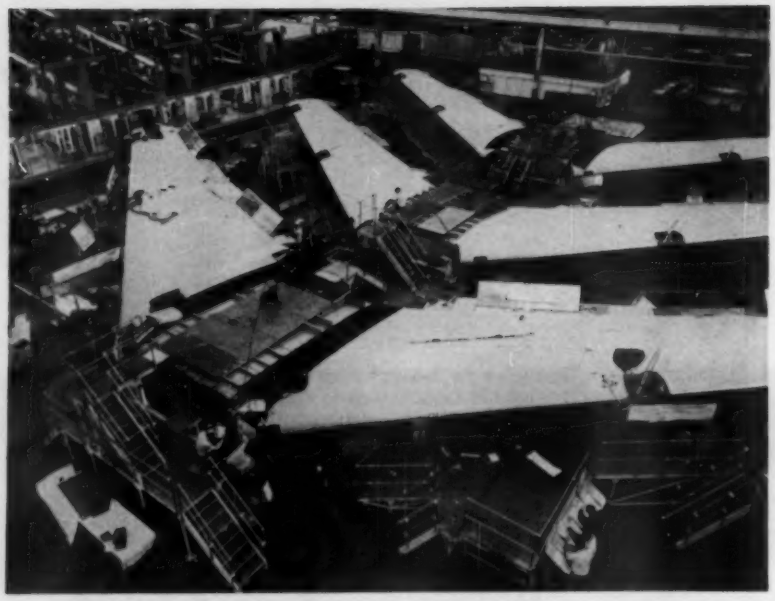

BOAC's Boeing 707-420 Wing Assembled

Wing for the first British Overseas Airways Corp.'s Boeing 707-420 Intercontinental (foreground) is assembled at Boeing's Renton, Wash., plant. The 707-420 will be the first of its type to be equipped with Rolls-Royce Conway Co. 10 turbojet engines. BOAC has 15 Intercontinentals on order, with first deliveries scheduled for this year.

portions of it were missing. No fire damage was present on these pieces of wreckage. The fillet covering the lower portion of ths area was flattened inward by inflight impact, was covered with pock marks from shattered glass fragments, and had numerous scrape marks running downward and inward at various angles. There were white paint deposits in some of the scratches and black deposits on those more parallel with the longitudinal axis.

The left side of the center portion of the fuselage remained attached to the wing structure. There were minor scratches and distortions of this wreckage but no pattern of inflight impact damage could be ascertained.

Right Side Torn

The right side of the aft fuselage was torn and crumpled owing to forces acting rearward, downward, and inward. The lower right side aft of the attachment to the fuselage center section was covered with scratches running downward and rearward at about 45 deg. to the longitudinal axis of the airplane. There were white paint smears in the same general direction and pock marks from shattered glass fragments. The impression left by contact with the rams horn antenna was aft and above this area. Scratch marks from this impression extended down and rearward through the USAF roundel on the side of the fuselage.

The T-33 right tip tank received extensive inflight impact damage. The nose section had separated and was crushed inward with diagonal accordion-like pleats which indicated inward and rearward acting loads. In the green painted area just inboard of the top center of the tank there were scratches from a double row of rivets extending across the troughs and crests of the pleats. These rivet scratches ran inboard and aft at an angle of approximately 47 deg. to the longitudinal axis of the tank. On the outer side near the front end of this section of tank there was an impression made by the windshield alcohol de-icer filter of the Viscount This filter is located at station 110, on the left side of the Viscount fuselage, eight inches inboard of the skin and 12 in. below the floor-line.

The indentation from the Viscount nose gear pivot support previously mentioned was also on this portion of tip tank, approximately 17 in. forward of the joint where this section joins the cylindrical section of tank and a few inches above the centerline of the outboard side. Also at the centerline and about three inches ahead of the joint there was a distinctive rivet pattern made by flush rivets at the skin seam on the left side of the Viscount at station 132 between stringers 56 and 57.

The cylindrical or center section of the tank was severely distorted and torn. Inboard of the top centerline the aforementioned pattern made by the brazier head rivets, from the left side of the Viscount below the front loading door, ran nearly 90 deg. to the longitudinal axis of the tank. There were also some accordion-like pleats running fore and aft along the top centerline of the tank. The rivet pattern scratches ran into some but not all of these pleats. The tail cone or rear section of the tip tank also showed this pleating effect along its top center. In addition, there were numerous rivet scratches on its outer upper surface running inboard and aft at an angle of about 45 deg. from the longitudinal axis.

The T-33 entire right wing was shattered from the tip inboard to a line running inboard and aft at approximately 35 deg. from station 93 at the leading edge. Pieces of the top surface of wing and aileron from this area were heavily scratched and bore light blue and white paint marks. The scratches, which were found only on the upper surface, ran inboard and aft at angles of approximately 42 deg. to 45 deg. to the longitudinal axis of the aircraft. The fractures in the shattered wing were consistent with downward and rearward-acting loads.

One six-foot section of top surface stringer with pieces of skin attached was concaved downward. The most inboard detached piece of front upper spar cap extended from station 65 to station 105. At station 90 on the top surface of this piece there was heavy gouging and it was concaved downward. From this point inboard to the break, the spar cap was twisted nose down and bent aft and downward approximately 30 deg. The most inboard detached piece of rear upper spar cap extending from station 32 to station 116 was bowed rearward about 20 deg. No inflight impact markings were found on the left wing.

T-33 Empennage

The main part of the T-33 empennage was found in one piece. With the exception of the right horizontal surfaces, very little damage was noted. The right horizontal stabilizer was severed and fragmented outboard of a line from station 40 at the leading edge to station 30 at the rear spar. Most of the tip portion was accounted for in two pieces. The forward piece was deformed inward and rearward and bore numerous light blue paint smears. Approximately one square foot of skin remained attached to this piece. There were scratches and blue and white paint deposits on the top surface in two different patterns. One pattern ran rearward and inboard at an angle of about 35 deg. to the centerline of the airplane, the other was at an approximate angle of 45 deg.

Examination of the Viscount engines and propellers disclosed no evidence of operating difficulties prior to impact. As stated, the four engines remained in their approximate relative positons to the main wing spar and all four propellers were tight on their shafts.

The propeller blades, in addition to the damage previously mentioned, were bent in various directions and angles. The pitch changing mechanism in each was in good condition. The No. 1 and 2 propeller piston positions were 84 deg., 20 min. and 74 deg. 30 min., respectively, in the feather range. The No. 3 and 4 were positioned at 42 deg., 30 min., and 41 deg., respectively. The propeller control units on the No. 1 and 2 were found in the feather and one-sixteenth inch from feather position, respectively. The shutoff cock on the fuel control unit for No. 1 engine was halfway between closed and feathered position, while that for No. 2 was closed.

The control pedestal was broken free of the cockpit area and found approximately one-fourth of a mile from the cockpit floor. The positions of throttles on this section of pedestal were found to be one-half open. The positions of the controls and the No. 1 and 2 propellers in the feather range, are not considered as reliable evidence of their operational positions prior to the accident. The distortion and mutilation of the engine control systems, sustained in the collision,

could have repositioned the controls to the settings found during examination.

All four engines showed similar damage from ground impact and ground fire. The engine mount struts were bowed and the engine mount attachments were broken. The turbine assemblies were crushed by the airframe firewall and the auxilary gear case.

The T-33 engine struck the ground, accessary section first, disintegrating that section as well as the accessory drive and compressor sections. The turbine buckets were broken from the turbine wheel but did not indicate evidence of rotation at ground impact. This was also true of the vanes of the compressor unit. All the evidence indicated that the engines of both aircraft were operating normally prior to collision.

Maintenance records for both aircraft indicated they were maintained in an airworthy condition in accordance with applicable regulations. There were no outstanding discrepancies affecting their airworthiness.

Title I of the Civil Aeronautics Act of 1938, as amended, charges the Board with the responsibility for prescribing and revising Air Traffic Rules to regulate air commerce in such a manner as to best promote its development and safety. The statutory authority for the promulgation of these Air Traffic Rules is set out with particularity in Title VI of the Act. In addition, the procedure the Board must follow in its rule-making function is governed by the Administrative Procedures Act.

This statutory authority was described by a witness from the General Rules Division, Bureau of Safety, Civil Aeronautics Board, at the public hearing. Part 60 of the Civil Air Regulations has been developed by the Board pursuant to this authority to govern the operation of all aircraft, civil and military. There are two major sets of rules contained in this part. First, the Visual Flight Rules (VFR) which have been developed on the principle that when weather conditions are above certain minimums pilots will be able to see and avoid other aircraft. The second group of rules governs the operation of aircraft when weather conditions are below these minimums when it is assumed pilots will not be able to see and avoid other aircraft. These rules are known as Instrument Flight Rules (IFR) and under them Air Traffic Control (ATC) guarantees separation from other controlled aircraft. Generally, if there is a ceiling of less than 1,000 ft. or visibility less than three miles in controlled airspace, an aircraft cannot be operated according to VFR. In addition, an aircraft while operating in weather conditions above the minimum may not be flown closer than 2,000 ft. horizontally, 500 ft. vertically underneath, or 1,000 ft. vertically on top of clouds. If the ceiling or visibility is less than these minimums, or these minimum distances from clouds cannot be assured, a pilot must operate in accordance with IFR. In addition, a pilot may elect to conduct his flight in accordance with IFR even though weather conditions are above the minimums. In this event, because the weather is above the minimum, other aircraft can be operated according to VFR without knowledge of ATC. Under these circumstances the

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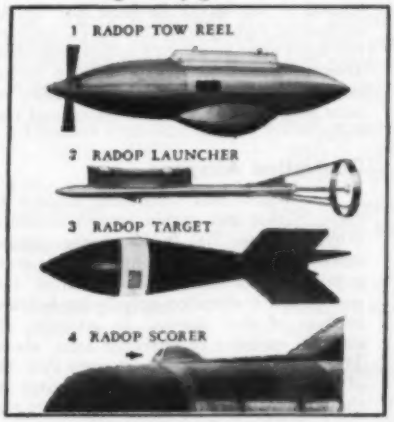

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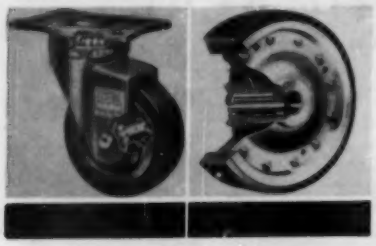

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pilot operating in accordance with IFR is guaranteed separation only from other aircraft similarly operating according to IFR. He must, therefore, maintain the same degree of vigilance, required during VFR operations to see and avoid other aircraft.

The witness defined "positive control" as a traffic control which provides separation between all aircraft notwithstanding weather conditions. After many months of study by the Board the initial step for this control has been taken. The Board has adopted regulations for positive control at high altitudes on certain specified routes. Heretofore, the limiting capabilities of air traffic control facilities have made this infeasible. Expansion of this program will be accomplished as rapidly as increased air traffic control capabilities permit.

Elsewhere positive control is not exercised except when the weather conditions are below VFR minimums and then only in controlled airspace. Pilots operating VFR in controlled airspace are required to maintain cruising altitudes in accordance with those designated for the particular airway they are using. In uncontrolled airspace the altitudes are governed by quadrantal rules, i.e., a certain altitude designated for a particular compass heading. These rules apply only to an aircraft in level cruising flight and do not apply to aircraft climbing or descending.

The witness also testified that the right-of-way rules which are applicable in VFR flight are set out in Part 60. Part 60 of the Civil Air Regulations applies to all types of aircraft operating in the U. S., civil and military. In addition, all Air Force aircraft must be operated in accordance with the provisions of Air Force Regulation 60.16, which is essentially the same as CAR Part 60 but may contain more stringent rules applicable to some operations. The witness said the two regulations are not in conflict but if they were Part 60 would govern.

A witness for the Civil Aeronautics Administration testified that the primary purpose of the Air Traffic Control service is to provide for the safe and efficient operation of aircraft operating according to instrument flight rules. In order for a pilot to avail himself of this service he must first file an instrument flight plan with an ATC facility. His flight must be planned within controlled airspace. He must obtain an air traffic clearance prior to taking off and, finally, he must adhere to the clearance throughout the flight.

Controlled Airspace

The witness said controlled airspace is normally that area within airways structure extending from 700 ft. above the ground upward to infinity. In terminal areas controlled airspace extends upward from the ground and is extended laterally beyond the confines of civil airways. In addition, all airspace, exclusive of restricted areas, above 24,000 ft. is controlled airspace. Part 60 of the Civil Air Regulations delegates to the Administrator of Civil Aeronautics the responsibility and authority to designate controlled airspace and when the Administrator has determined that IFR traffic density justifies it an airway is designated. Airways are provided with radio facilities making it possible to navigate along the airway by the use of instruments and radio. The airspace over the accident area is such controlled airspace and is defined as Victor Airway 44.

CAA maintains an extensive network of air-ground communications for the purpose of efficiently controlling IFR traffic. Washington Center, which controls all IFR traffic in a designated area around Washington, within which the accident occurred, is equipped with such communication equipment. All IFR traffic, civil and military, is handled with this equipment.

The witness stated that Washington Center is also equipped with radar which is used to augment the basic non-radar system of air traffic control. If the traffic can be seen and identified on the scope, control can be exercised by radar. If the target fades or contact is lost, control reverts to the basic non-radar system. He said radar is used in conjunction with air traffic control services rendered between Martinsburg and Baltimore. Radar-assisted air traffic control also provides pilots with advisories on all observed targets. This service may be limited by the radar coverage and volume of traffic and workload. In addition, many pilots do not desire the service and request that it be withheld.

The witness said that because of the poor return from a T-33 type aircraft, it would present a poor target for radar in the Brunswick area below about 8,000 ft. The Viscount under the same conditions, however, being a larger aircraft, presents a good return and would be readily identifiable. Because of this uncertain return from the jet trainer, he doubted that the faint target seen by the controller was from the T-33. The enlarged "blip" seen on the screen may have been but was not necessarily the collision.

Flying Area

A representative of the Air National Guard testified at the public hearing. He said that Martin Airport is located in an area completely surrounded by controlled airspace or restricted areas. An area roughly 100 mi. square has been designated around the airport as a local flying area. In it, acrobatic and engineering flights are conducted off airways but because of the concentration of airways in the area all other types of training flights are of necessity flown in controlled airspace. Various congested areas, restricted areas, and Air Defense Identification Zones (ADIZ) within the area are avoided.

The establishment of the local flying area was coordinated with the Aberdeen Proving Ground as the ANG is allowed to use part of this restricted area for training. Departure and arrival corridors have been set up through this area to avoid congested areas and reduce conflict with other traffic as much as possible. It was not considered necessary to issue NOTAMS describing the ANG activity because of the relatively small amount of traffic generated at the base—about 100 flights per week. The squadron training procedures stress the necessity and importance of pilot vigilance and that Civil Air Regulations place the responsibility on the pilot to avoid collision under VFR conditions.

The witness testified that certain Standing Operating Procedures (SOP) have been established in the squadron. These are

operating rules for the squadron and do not carry the same weight as Air Force Regulations in that they are written at squadron level. SOP's covering operational phases in the squadron are constantly monitored by the operations officer and if it is determined one has been violated disciplinary measures are taken.

The witness stated that subsequent to this accident the Air Force accepted certain voluntary flight restrictions. The resulting directives are voluminous but basically the effect is to preclude nontactical flying in jet aircraft below 20,000 ft. under visual flight rules. They also direct other similar action be taken to reduce as much as possible any conflict with other traffic. These directives again caution pilots about the provisions of regulations requiring a constant vigilance to prevent the recurrence of similar collisions.

Airline Training

The Capital Airlines training curriculum was described by a company official at the public hearing. All new pilots are given a three-week course of instructions in Civil Air Regulations, company policy, and operations, as well as flight and simulator training. Each pilot is given and required to study two manuals which include the pertinent Civil Air Regulations. In addition, all captains are required, twice yearly, to demonstrate proficiency in flying as well as knowledge of Civil Air Regulations, company policies, and the aircraft in which they are qualified. In all copilot instruction and/or upgrading, knowledge of Civil Air Regulations must be demonstrated. The company also constantly publishes operational bulletins concerning, among other things, air traffic control and cockpit vigilance.

The witness said that all CAP flights in the "Golden Triangle" (an area bounded by an imaginary line drawn between New York City, Chicago, Washington, and back to New York) are operated according to IFR above 9,500 ft. Pilots will not accept VFR climbs or descents above this altitude, nor will they accept VFR on top in this area, except in emergency. In addition, CAP, since the accident, has applied this "Golden Triangle" rule to all its flights. VFR climbs and descents and VFR flight may be conducted below 9,500 ft. but not above this altitude. It is company policy that all scheduled flights be conducted on airways or on approved off-airways routes. Below 12,500 ft. on approved off-airways routes flight may be planned and flown according to either IFR or VFR, except when weather conditions permit only instrument flight. Above 12,500 ft., on approved off-airways routes, pilots must file an IFR flight plan but must operate according to VFR.

The witness said that clearing "S" turns during climbs and descents are not required by Civil Air Regulations, but the pilots are constantly reminded of the need for keeping alert and vigilant to see other traffic. In addition, there is contemplated a policy revision requiring clearing maneuvers during descent. The V_{no} (velocity normal operation) of the Viscount is 238 kt. indicated and this is the maximum operating speed permitted in descent except for emergency. A company rule states that logbook nota-

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tions will not be made during climb or descent or in congested areas. CAP continuously conducts flight checks to ensure compliance with all regulations and to ensure cockpit discipline to further safety and efficiency of flight.

During the investigation it was learned that the T-33 pilot had been involved in two previous collisions and one major landing accident. Also, the copilot of the Viscount had been involved in a collision and one other incident.

The first of Capt. McCoy's collisions occurred when another airplane on an aerial gunnery mission made a simulated firing pass on his aircraft. The pilot misjudged and collided with Capt. McCoy. The second collision occurred when Capt. McCoy, in a close formation acrobatic maneuver, was unable to effect control and slid into the lead aircraft. In the other accident, Capt. McCoy made a hard landing and damaged the aircraft so that a major component had to be replaced. The copilot of the Viscount had, while on active duty with the U. S. Navy, collided with a towed aerial target while on an aerial gunnery mission. On another occasion he had experienced an engine flameout in a jet aircraft and was forced to "bail out."

It is evident from the nature of these accidents that they in no way indicate a lack of training or patterns of behavior which are of significance to this investigation.

ANALYSIS

It appears probable to the Board that the faint return on the radar-scope followed by the enlargement of the Viscount target seen by the center controller working Flight 300 was, in fact, the collision. No other reasonable explanation can be advanced to account for these observations. Allowing 10 sec. (one sweep of the radar antenna) for the controller to verify the target first observed and 8 sec. for evaluation and initiation of his transmission, it was possible to estimate closely the time of the accident. As stated before, the controller's transmission was made three minutes and three seconds after Flight 300 had reported over Martinsburg at 1126. Subtracting the 18 sec. estimated to have elapsed prior to the call, it is determined the accident occurred about 2 min. and 45 sec. after 1126. As the point of collision, determined from ground witnesses, was 14 mi. from Martinsburg, it was calculated that the ground speed of the Viscount was approximately 304 kt. With corrections for altitude, temperature, and wind it was further calculated that the indicated airspeed of the Viscount was about 235 kt. This speed is approximate and may vary slightly but it is within the range of normal operation. Any variation in this speed would not affect this analysis, which is based on damage patterns and which indicates relative motion only between the two aircraft.

From a study of the in-flight damage to the two aircraft, it was determined that initial contact between them was when the nose section of the T-33 right tip tank struck the left side of the Viscount fuselage just ahead of station 132 below the floorline. As a result of this impact the nose section of the tank was crushed inward and rearward. Rivet scratches on the tank

T-33, Viscount Angular Relationships

Time to collision in seconds	Angle of T-33 from Viscount in degrees to left of nose	Angle of Viscount from T-33 in degrees to right of nose	Distance between airplanes in feet
5	90	55	1,700
10	93	61	3,150
15	97	65	4,200
20	102	68	5,000
25	107	70	5,450
30	113	67	5,650
45	126	54	6,40
60	136	44	,450

also running inward and rearward confirm the fact that the damage resulted from loads acting inward and rearward at an angle of approximately 47 deg. The Viscount fuselage conversely was destroyed by loads acting from left to right with some indication of an upward component at station 132.

Following this initial impact, which separated the nose section from the T-33 tip tank, the main section of tank contacted the Viscount fuselage below the forward entrance door. The next area of impact was between the T-33 wing and the Viscount fuselage, upward and forward of the initial impact area. This destroyed the right wing of the T-33 and shattered the nose structure of the Viscount. The forces which destroyed the wing acted rearward, inboard, and downward as evidenced by the bending of the front spar upper cap and scratches runing aft and inboard at angle of 42 deg. and 45 deg. on the top surfaces of wing fragments.

Damage to the Viscount nose structure was caused by loads acting predominantly from left to right.

Fuselage Scratches

The outer portion of the right horizontal stabilizer of the T-33 was destroyed when it struck the upper left Viscount fuselage between stations 198 and 232. Scratches found on fragments of this structure ran aft and inboard at angles of 35 deg. and 45 deg. Again the damage to the Viscount was due to forces acting from left to right.

A study of this damage showed best agreement in matching the observed collision damage of the two aircraft when the longitudinal axes were pointed toward each other with an angle of approximately 42 deg. between them and with the aircraft rolled into one another with an angle of approximately 25 deg. between the vertical axes. With this relative attitude constant during the period, there was generally good correlation between the damage from the time the nose section of the tip tank contacted the Viscount fuselage until the T-33 right horizontal tail hit. Because the vertical closure between the two airplanes was obviously small, it was assumed to be negligible as compared to the horizontal closure.

From this study it was determined that the airspeed of the T-33 was approximately 55 kt. greater than that of the Viscount at the instant of impact. The rate of closure between them was approximately 195 kt.

It is significant that the eyewitness' descriptions of the collision are entirely consistent with the inflight damage to the two aircraft. The Board believes, from all the evidence, that the Viscount was flying a straight course but descending at a normal rate and at an indicated airspeed of approximately 235 kt.; further, that the T-33 was flying a straight course which was parallel and to the left and behind the Viscount. Although in a shallow climb of a few degrees, its airspeed was higher and it was overtaking the Viscount. A short interval before colliding the T-33 began a normal right-hand turn and continued in this turn until striking the side of the airliner. Although the T-33 was in a slight climb and the Viscount was in a descent, it is doubtful that the small vertical closure would be perceptible to ground witnesses.

Based on the above mentioned evidence, a study was made of the relative opportunities for the various crew members to see the other aircraft during the 60 sec. immediately prior to collision. At the instant of impact the flight path of the Viscount was assumed to be straight while that of the T-33 was assumed to be in a coordinated turn to the right. At an angle of bank of 25 deg. and an airspeed of 290 kt. IAS (551 ft. per second true), the T-33 would have a radius of turn of about 20,300 ft. To have struck the Viscount at an angle of 42 deg., the T-33 would have had to have started its turn about 26 sec. before collison from a parallel course about 5,200 ft. to the left.

Pilot Visibility

A comparison of angles (see table) with the cockpit visibility charts for the Viscount shows that the copilot could not have seen the T-33 until at the instant of impact. The pilot could not have seen the T-33 until about 26 sec. prior to collision because of the intervening fuselage aft of his left window.

As for the T-33 pilot, there was no obstruction to his seeing the Viscount for well over a minute before collision.

From a study of weather reports for the area, supported by testimony of ground witnesses, it appears most likely that the cloud coverage below 12,000 ft. in the accident area consisted of 1- to 2/10ths of fair weather cumulus clouds based at approximately 4,500 ft. with very little vertical development. One or two eyewitnesses

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stated that the jet momentarily passed through or behind one of these small clouds, but all witnesses were in general agreement that both aircraft were clearly visible for a considerable period of time prior to the collision.

Civil Air Regulations require that all pilots in VFR weather conditions maintain separation from other traffic visually, irrespective of the type of flight plan or clearance. In addition, these regulations have established right-of-way rules governing the flight of converging aircraft. Here the evidence shows that both aircraft were being operated in VFR weather conditions; also, that the T-33 was behind and overtaking the Viscount. Civil Air Regulations clearly state that an aircraft being overtaken has the right-of-way. The overtaking aircraft, whether climbing, descending, or in horizontal flight shall keep out of the way of the other aircraft by altering its course to the right, and no subsequent change in the relative position of the two aircraft shall absolve the overtaking aircraft from this obligation until it is entirely past and clear.

The evidence is clear that the T-33 pilot had ample opportunity to see the Viscount and avoid it.

With respect to the Viscount, whether the 26-sec. sighting possibility is adequate is less clear. Numerous studies have been conducted on this subject and the conclusions reached are nearly as numerous. Most of these studies agree that after another aircraft is sighted evasive action can be accomplished in less than 26 sec. An area of disagreement exists, however, as far as the time required to scan for and detect other aircraft and to determine that a collision course exists.

In this accident it is obvious the Viscount pilot did not see the T-33. It is fundamental that a pilot's primary responsibility is to direct his attention to the most critical area, which is ahead of the aircraft. This is in no way intended to mean pilots should not look around and take any action necessary to avert collisions. It does mean, however, that a greater degree of vigilance is required in the direction the aircraft is flying.

In this collision the T-33 could have been seen about 26 sec. before collision. The Board does not believe that the fact the Viscount pilot did not see the T-33 in this period of time indicates a lack of vigilance. It is believed there may be periods of time considerably longer than this in which a pilot may not have the opportunity to clear behind him. It is not unreasonable therefore to place responsibility for collision avoidance on the aircraft which is behind and overtaking and, in fact, under the Civil Air Regulations, the overtaking aircraft is clearly burdened to see and avoid other aircraft.

As stated before, the Board believes that the collision was observed on the radarscope by the controller. It is tragic that no return was received from the T-33 in time for the controller to take action to alert the crew of the Viscount. As more advanced and sensitive equipment is developed, many limitations of radar traffic control will be alleviated and it should be possible to prevent this type of aircraft accident.

CONCLUSIONS

From all the available evidence the Board concludes that the weather at the flight altitude was VFR and that both aircraft would have been free from clouds about 9/10ths of the time without taking any action whatsoever.

It is also evident that Capt. McCoy, from his overtaking position, had ample opportunity to see the Viscount ahead of him and take evasive action. No unusual cockpit distractions or structural limitations to visibility precluded him from maintaining a lookout for other traffic. The Board believes that Capt. McCoy was not exercising the normal lookout for other aircraft required and expected of him. Had he done so, this accident might well have been avoided.

Conversely, the Board does not believe the Viscount pilots' failure to see the T-33 in the 26 sec. which it could have been seeen is evidence of a failure to maintain a normal vigilance.

The Board is mindful of a current consensus concerning the obsolescence of the visual flight rules. We recognize the fact that these views frequently involve generalizations based upon assumptions of extremely high closure rates. However, prohibitively high aircraft closure rates were not involved in this accident. A requirement still exists for the continuation of visual flight rules substantially as contained in the present Civil Air Regulations for the large majority of aircraft operations such as those with which we are here concerned.

With this, all responsible spokesmen for the principal airspace users, including military and civil, are in agreement. Emphasis must again be made, therefore, on the fact that the obligation to see and avoid other aircraft under visual flight rules conditions constitutes a condition precedent to the use of navigable airspace. This responsibility cannot be evaded by allegations that the Civil Air Regulations are inadequate or obsolete or that traffic control procedures which allow visual flight are improper.

Accordingly, the air traffic rules clearly establish that failure to maintain a constant vigilance for other air traffic endangers the lives and property of others and, therefore, constitutes a disregard for the safety of other users of the airspace. A corresponding responsibility flows upon the operating agency which must maintain vigorous training and indoctrination programs in which cockpit vigilance is the subject of continuous emphasis and surveillance and in which failure to maintain such vigilance is subject to effective corrective action.

Subsequent to this accident the Air Force published directives requiring that the operation of all aircraft along airways, between 10,000 and 20,000 ft., be according to IFR. However, pilots may accept VFR climb or descent restrictions. In addition, some Air Force commands have imposed further restrictions on locally based jet aircraft which essentially preclude their operation below 20,000 ft. under visual flight rules.

Since this accident Capital Airlines has required that all its flights be conducted according to the procedures set out for the "Golden Triangle," i. e., aircraft above 9,500 ft. on airways must be operated ac-

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cording to IFR. VFR restrictions on climb and descent will not be accepted above this altitude.

PROBABLE CAUSE

The Board determines the probable cause of this accident was the failure of the T-33 pilot to exercise a proper and adequate vigilance to see and avoid other traffic.

By the Civil Aeronautics Board:

James R. Durfee
Chan Gurney
Harmar D. Denny
G. Joseph Minetti
Louis J. Hector

SUPPLEMENTAL DATA

The Civil Aeronautics Board was notified of this accident shortly after it occurred. Investigators were immediately dispatched to the scene and an investigation was initiated and conducted in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. A public hearing was ordered by the Board and held at the Department of Commerce Auditorium, Washington, D. C., on June 30, July 1, and July 2, 1958.

Capital Airlines, Inc., is a Delaware corporation and maintains its principal offices in Washington, D. C. The corporation holds a current certificate of public convenience and necessity issued by the Civil Aeronautics Board to engage in the transportation of persons, property, and mail. It also possesses a valid air carrier operating certificate issued by the Civil Aeronautics Administration.

The Maryland Air National Guard is a reserve component of the USAF. The 104th Fighter Interceptor Squadron (Maryland ANG) is a unit of the 113th Fighter Interceptor Wing. Training for the squadron is conducted to qualify the members of the unit to fulfill a mobilization assignment with the USAF at such times at the national security requires.

Capt. Kendall J. Brady, age 38, was employed by Capital Airlines June 11, 1945. He held a valid airman certificate with an airline transport rating for airplane, multi-engine land, Douglas DC-3 and DC-4, and Vickers Viscount. Capt. Brady had a total of 12,719 flying hours, of which 1,432 were in the Viscount. He passed his last first-class physical examination on April 15, 1958. He received his last semiannual proficiency check on Nov. 25, 1957, and his last line check Mar. 25, 1957.

Mr. Paul F. Meyer, age 26, was employed by Capital Airlines, May 25, 1956. He held a valid airman certificate with a commercial pilot rating for single- and multi-engine land aircraft, and an instrument rating. He had a total of 2,467 flying hours, of which 1,596 were in the Viscount. He passed his latest first-class physical on May 20, 1957.

His last copilot proficiency check and semiannual instrument certification was given Dec. 14, 1957.

Capt. Julius R. McCoy, age 34, was rated as military pilot Aug. 4, 1944, upon successful completion of the aviation cadet training course. He joined the Maryland Air National Guard in 1952. He had a total of 1,902 flying hours in single- and multi-engine and single-engine jet aircraft. He had a total of 597 hr. in single-engine jet aircraft, of which 210 were in the T-33. His latest medical examination was passed Jan. 3, 1958. His latest instrument certification was given Dec. 19, 1957.

THE AIRCRAFT

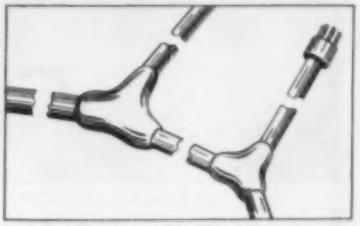
The Viscount. N 7410, a Vickers Viscount, model 745, was manufactured in the United Kingdom Jan. 15, 1956. It was acquired by Capital Airlines on Jan. 24, 1956. Records showed the aircraft was maintained in accordance with applicable regulations. The aircraft was equipped with Rolls Royce Dart engines, model 510, and Rotol propellers, model No. R130/4-20-4/12.

The T-33. AF 35966, a Lockheed T-33, was maintained by the Maryland Air National Guard in accordance with all applicable Air Force maintenance regulations. It was equipped with an Allison engine, model J33-A-35.

CABLE and WIRE LEADS

by HOWARD E. PENDERGAST
Technical Director, Rex Corporation

Engineering reliability into cable assemblies



CABLE ASSEMBLY RELIABILITY is the sum of the reliabilities of conductors, insulation, cabling, soldering and connectors. The integrated handling of all variables by one dependable source is the surest preventive of cable assembly failure.

Malfunction of electrical and electronic equipment is a common field problem. Cable assemblies rank high on the list of causes. Reasons include: wire fatigue, insulation break-down, faulty soldering of terminations, excessive rigidity in connectors, end break-ott or poor contact under shock and vibration, grounded or contaminated hermetic seals.

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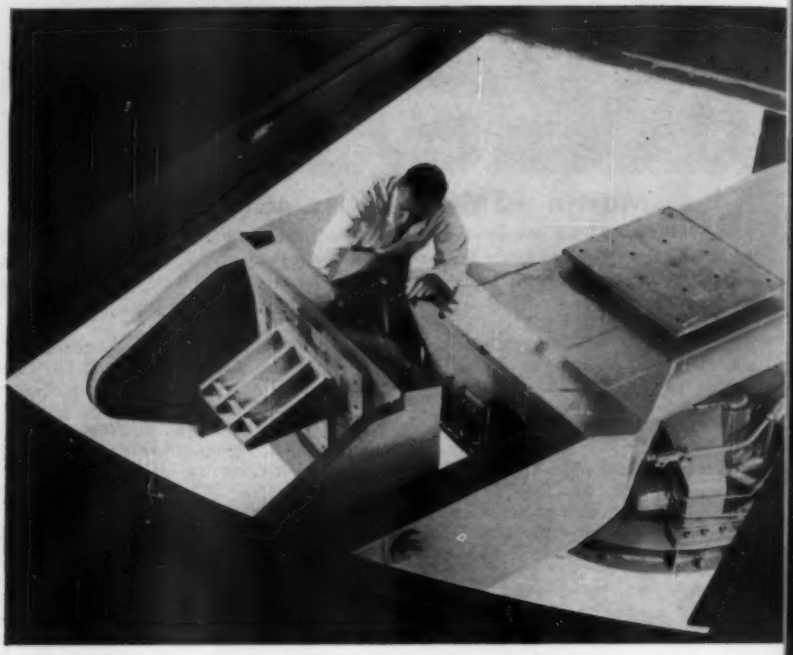
(left) Pop-up test of Navy Polaris IRBM.

(below left) One of the Santa Cruz test stands with dynamic thrust mount to simulate flight environment. Vibration oscillator functions during static firings.

(below right) Large centrifuge for environmental testing has unique shaker attachment to provide vibration simultaneously with high G-loadings.



EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

...Test

Testing is a vital part of every stage in the development of missile and space programs at Lockheed Missile Systems Division.

The Division maintains one of the most completely equipped missile and space test laboratories in the world. Equipment includes: altitude, temperature and humidity chambers; shaker and vibration systems; G-accelerators; and apparatus capable of performing chemical, metallurgical, plastic, heat transfer, hydraulic, pneumatic, shock, acceleration, sinusoidal and random vibration, structural, electrical, and electronic tests. Static field testing; research and development testing on controls; testing in ordnance and hydraulics and high-pressure gas and propulsion systems are conducted at the 4,000 acre, company-owned test base in the Ben Lomond mountains near Santa Cruz, California.

As weapons systems manager for such major, long-term projects as the Navy Polaris IRBM; Discoverer Satellite; Army Kingfisher; Air Force Q-5 and X-7; and other important research and development programs, Lockheed is engaged in expanding the frontiers of technology in all areas.

Flight testing is conducted at Cape Canaveral, Florida; Alamogordo, New Mexico; and Vandenberg AFB near Santa Maria, California; in a unique manner. All components and sub-systems of a new project are initially tested on known-performance, production missiles. Thus, when the final system is ready for first flight, its individual components already have flight-tested reliability. This new concept of flight testing is a major contribution and has enabled Lockheed to produce extremely complex missile systems in record time and at greatly reduced expense.

Underwater launch tests—including studies of cavitation, wave simulation and skip motion—are carried on at the Sunnyvale facility and at the Navy test base on San Clemente Island. In addition, structural and other tests are performed at Hunter's Point Naval Shipyard, California.

If you are experienced in any of the various phases of testing, we invite your inquiry. Positions also are available for persons experienced in physics, mathematics, chemistry, or one of the engineering sciences.

Write: Research and Development Staff, Dept. B-17, 962 W. El Camino Real, Sunnyvale, California; 7701 Woodley Avenue, Van Nuys, California; Suite 745, 405 Lexington Avenue, New York 17, New York; Suite 300, 840 N. Michigan Avenue, Chicago 11, Illinois.

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CAPE CANAVERAL, FLORIDA • ALAMOGORDO, NEW MEXICO

WHO'S WHERE

(*Continued from page 23*)

Changes

United Aircraft Corp.'s Research Department, East Hartford, Conn., has made the following appointments: **Wesley A. Kuhrt,** chief of research activities; **Richard C. Molloy,** chief of technical operations; **George F. Hausmann,** chief research engineer; **Irving Twomey,** chief of test operations; **Stuart L. Crossman, Jr.,** chief of computational services; **Arthur E. Wetherbee, Jr.,** chief of departmental services.

Walter W. Micher, engineering manager, Countermeasures Division, Sperry Gyroscope Co., Division of Sperry Rand Corp., Great Neck, N. Y.

Richard D. Fullerton, chief engineer, Systems Division, Pacific Automation Products, Inc., Glendale, Calif.

J. Vance Foster, applications engineering manager, Potter & Brumfield, Inc., Princeton, Ind.

E. L. Spencer, general manager, and **Gervase M. Magrum,** assistant general manager, Buffalo Hydraulics Division of Houdaille Industries, Inc., Buffalo, N. Y.

Arthur A. Fickel, manager-special programs section, General Electric's Defense Systems Department, Philadelphia, Pa.

Dr. Paul Webb, consultant in aviation medicine and environmental physiology, Aeronautical Division, The Firewel Co., Inc., Buffalo, N. Y.

Alfred V. Guillou, manager-marketing and requirements, and **Peter Horton,** manager-plans and programs, Douglas Aircraft Co.'s newly established Weapon Systems organization, Santa Monica, Calif.

LeRoy Palmer, staff assistant to the vice president and general manager, Dalmo Victor Co., Belmont, Calif.

Dr. C. E. Oelker, director of engineering, Cincinnati Division of Bendix Aviation Corp., Cincinnati, Ohio.

The Boeing Airplane Co., Seattle, Wash., has announced the following appointments for the Minuteman ICBM program: **Ron Langsford,** manufacturing operations chief; **Jack Metcalf,** section chief-manufacturing production control; **A. J. Rorstad,** section chief-industrial engineering. Boeing also announced the following appointments for the Systems Management Office: **F. P. Krippaehne,** head-operational facilities section, operation programming branch; **N. D. Morgan** succeeds Mr. Krippaehne as facilities planning assistant; **Arthur R. Thompson** succeeds Mr. Morgan as property management assistant.

Dr. R. J. McNair, head of the advanced project activity, Traffic Control Systems Engineering Department, Crosley Division, Avco Manufacturing Corp., Cincinnati, Ohio.

Richard W. Baker, director of commercial sales, and **C. C. Potter,** director of agency, interline and vacation sales, American Airlines, Inc.

Dr. Bernard Litman, assistant chief engineer-research, and **Wen Tsing Chow,** assistant chief engineer-missile guidance, Arma Division, American Bosch Arma Corp., Hempstead, N. Y.

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STRUCTURAL R & D ENGINEER: To assume responsibility for improving and optimizing structural analysis methods and techniques. Current studies include development of fatigue criteria, nuclear effects on structures, thermal cycling, and associated high temperature studies, including creep effects, thermal stress, structural cooling, and insulation. This man will support advanced design efforts.

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Airline Pilot, 11,000 hours, desires corporation or executive flying position with opportunity to become part of management team. B. S. Degree. PW-9803, Aviation Week.

Comm. Pilot, 30, SMEL, instrument BSBA degree, airline and acft. design engr. experience. Desire multi-engine position as pilot or pilot/liaison engr. PW-9827, Aviation Week.

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SDC's projects constitute one of the largest Operations Research efforts in the history of this growing field. The projects are concerned primarily with man-machine relationships in automated systems in a number of fields, including air operations. The application of new and advanced digital computer techniques is particularly important in optimizing these man-machine relationships.

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Those who have professional questions or desire additional information are invited to write Dr. William Karush, Head of the System Development Corporation Operations Research Group at 2404 Colorado Avenue, Santa Monica, California.

"Method for First-Stage Evaluation of Complex Man-Machine Systems"

A paper by I. M. Garfunkel and John E. Walsh of SDC's Operations Research Group is available upon request. Address inquiries to Dr. William Karush at System Development Corporation.

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IN SUNNY SAN DIEGO

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Please send resume of your qualifications at the earliest opportunity to Louis Klein, Dept. E-339, Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, Calif.

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GENERAL ELECTRIC

Missile and Space Vehicle Department
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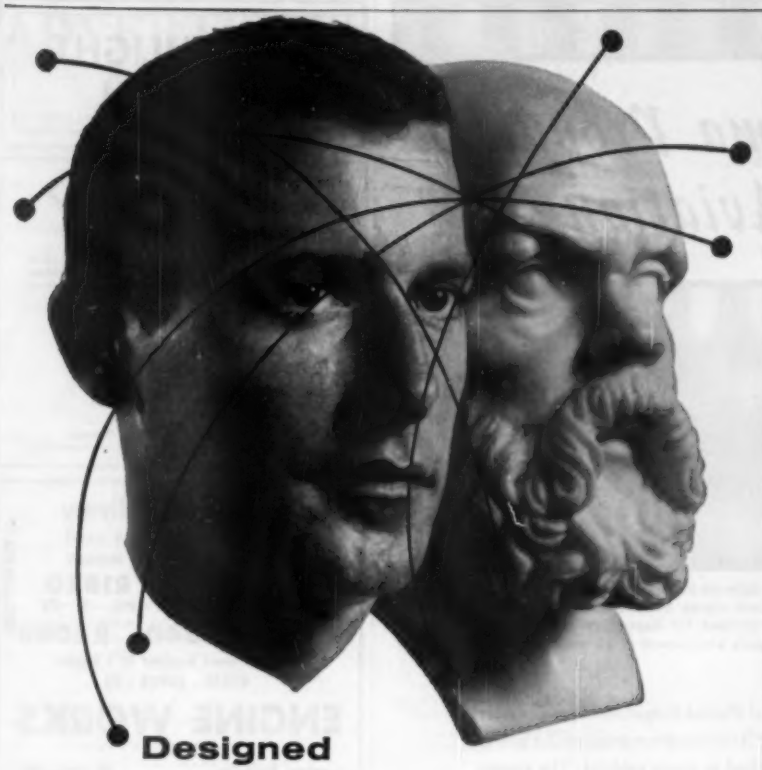
Philadelphia 4, Pa.



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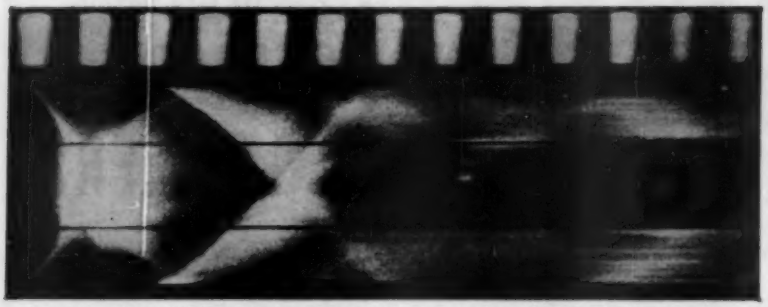
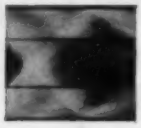
GENERAL ELECTRIC

REPORT ON

Plasma Propulsion at Republic Aviation



Space-Time Trace: With space as ordinate and time as abscissa, photograph shows development of pinch effect in plasma, followed by shock waves. Picture was obtained with special streak camera — part of the instrumentation devised for Republic's experimental Plasma Propulsion program. Each space at top measures an interval of 10 microseconds.



An experimental Plasma Propulsion System under test at Republic Aviation gives promise of a power plant ideally suited to space vehicles. The system generates plasma from a heavy gas and subjects it to magnetic acceleration to produce thrust at high exhaust velocity.

Research and Development in Plasma Propulsion and in a number of branches of Hydromagnetics and Plasma Physics is being sharply expanded as part of Republic's new $35,000,000 Research and Development Program. Investigations currently in progress include studies of plasma generation of electricity and the application of Hydromagnetics to Hypersonics.

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EXCITING NEWS See Page 83

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LETTERS

Soviet ICBM Range

In the Jan. 5 issue of AVIATION WEEK on p. 20 there was an article entitled, "Soviet ICBM Plans Discussed."

The article indicated that several theories have been propounded concerning why Mr. Khrushchev and the Russians picked 8,700 mi. as the range of their long-range ICBM [intercontinental ballistic missile]. (Nobody has yet stated whether they were talking about nautical or statute miles.)

I should like to mention that the Russians have some good solid bases at the South Pole left over from the IGY [International Geophysical Year] program which, for several reasons, might logically be used as launching sites for ICBMs; before you guffaw—the range from the South Pole up to 55 deg. north is—8,700 nautical miles. This just covers the main population area of the North American continent. It is also outside the reach and orientation of our BMEWS [Ballistic Missile Early Warning System] system to the north of us.

Much more could be said concerning the advantages of having a legal base of operations outside the limits of one's own country. In case of conflict, the U.S. retaliatory missiles would necessarily be split. Part of them would have to be used to eliminate further threat from bases at the South Pole, if they are able to reach it, and no other provisions have been made. The remaining units could be spent on their originally intended targets in Russia. In the meantime, if we have an anti-missile missile, the system may have been oriented in the wrong direction so as to have been totally useless.

Perhaps a little reconnaissance in the area of the South Pole is in order.

JAMES T. WRIGHT
Operations Research Engineer
Van Nuys, Calif.

Business Flying News

Don't like to gripe about things—but how about more news on the private flying angle? Small planes, business flying, etc.! I'm so sick and tired of reading about this "missile" and that "rocket," etc., that I just about declined from renewing my subscription. This goes for a lot of people here in flight test, I believe. What few articles you do have on the small stuff are very well written. How about a larger percentage of them?

CHARLES W. KEY
Seattle, Wash.

Technical Management

Space was given in AVIATION WEEK, Dec. 22 (p. 86), to J. K. Gerdel of the U.S. Army Transportation, Supply & Maintenance Command, St. Louis, Mo., who expressed some suggestions pertaining to the management of engineering projects by "non-engineering qualified managers."

To help dispel any illusions which this letter may have created among our younger and inexperienced engineers and technical people, it is requested that space also be given to the following comments.

Direct issue is taken with the thought expressed in Mr. Gerdel's letter, particularly

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with the fallacy that ". . . lack of specific technological training or experience will be no obstacle to the application of management techniques by one who has a firm grasp of such techniques," and also with his statement that "Numerous instances can be cited of the successful management of engineering personnel by non-engineering qualified managers."

Without going too far back into fundamentals it is the general belief of most reasonable men, as well as a proven fact, that for an individual to perform an intricate particular task well, he must be experienced in most or all of the particulars pertaining to the task. Inexperience will result in mediocre performance. Such is the way of life. For experience there is no substitute.

Likewise, in the management of those engaged in some such intricate and complex task, direct first-hand knowledge of the task or operation is absolutely a first and fundamental requirement if the manager is to make the intelligent and sound decisions he is called upon to make from day to day as the operation progresses. It is here assumed that policy is established at a higher level. Contrariwise, it should be obvious that a manager who is not versed in the particular field in which he is supposed to manage cannot possibly make correct decisions because he has no field of knowledge, no background upon which to draw. His "credit" is not one whit more than that of a man who tries to draw a check with no money in the bank to back it up—just about zero. Likewise is the measure of respect in which his associates hold him (assuming them capable of their tasks).

It is amazing to any experienced engineer that a thinking person, associated in the engineering field with competent people for any length of time, can hold that it is possible for engineering personnel to be successfully managed by "non-engineering qualified managers." If, in such a situation, any success seems to accrue, it is due no doubt to the persistent efforts of competent subordinates, tireless in their efforts to have truth reign supreme.

We are now deadlocked in a technology race with the Soviets. We are apparently unable to match, let alone surpass, the scientific and engineering skill, in several fields, of a nation which just 40 years ago was torn by a bloody revolution which wiped out the entire intelligentsia of the land.

This is a measure of the tremendous progress of the Soviets who started with so little. This is also a measure of our own ineffectual methods—we, who started with so much and yet have used so little of what we know. Whether we like it or not, this is the ground upon which the battle for supremacy is being fought. It is entirely possible that complacency and the unwise selection of engineering leaders, both in industry and in government, will be the deciding factors that tip the scales in this all out struggle. For world dominion today can be gained only through superior scientific and engineering achievements. These achievements depend in large measure upon the inspiration and direction of capable engineering leaders.

T. D. ROBINSON
Aeronautical Engineer
Newton, Conn.

Aviation Progress

I was not really too surprised to see the article which appeared in AVIATION WEEK ("Limited Certification," Nov. 10, p. 126), and I was quite proud when Experimental Aircraft Assn. member Harvey Mace came to the rescue with his fine well-worded reply (Dec. 15, p. 122).

As long as I can remember (and I have been active in this aviation business since 1936) I have seen one phase of aviation try to advance by stepping all over another. Aviation, as you know, isn't too much better off today than it was 30 years ago. It is continually aviation people working against each other rather than being united and advancing each phase and cause. Contrary to popular belief, it isn't the public that is in as great a need of aviation education and unification as it is the people in aviation itself.

I agree that it seems unreasonable that some of these finer type surplus military machines are not allowed to fly with some of the freedom that aircraft in other categories enjoy, but to sit back with pen in hand and lambast sport aviation in general and an educational organization such as ours and the Antique Aircraft Assn. serves no real useful purpose. To call personnel in the CAA "pigeon-brained powers" solely because they do not cater to your profit-making desires is also unfair.

I hesitate to ask how much sincere effort, time and travel the writer put into having the limited certification reconsidered. We have found that our fellow aviation enthusiasts who qualified for the civil service positions as CAA personnel have not lost their love for aviation as many people are so often led to believe, but when accepting these positions are bound by laws that have been inaugurated for many reasons.

We in the Experimental Aircraft Assn., and I believe I can speak for the Antique Aircraft Assn. also, whose combined membership is over 10,000, have been well pleased with government understanding and cooperation. True, in some instances we may not always agree but we sincerely realize that laws are not designed to please individuals but the majority. Possibly the sellers of high performance surplus weapons should get organized.

Remember, you can sell anything if you can justify it.

PAUL H. POBEREZNY
President
Experimental Aircraft Assn.
Hales Corner, Wis.

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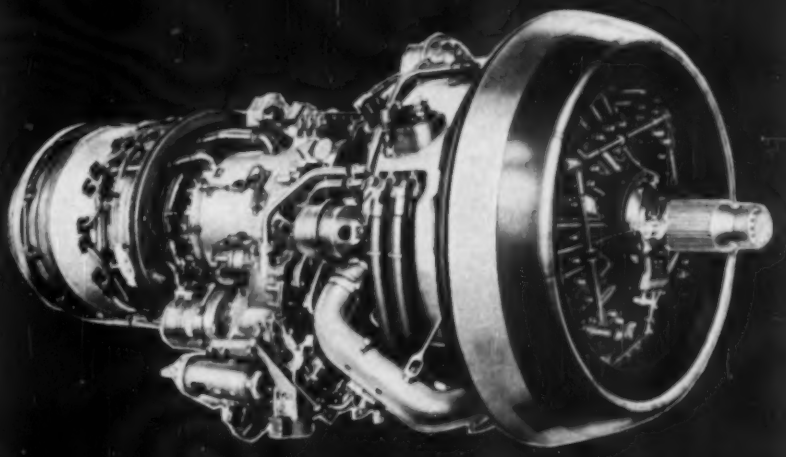
TYNE PROP-JETS



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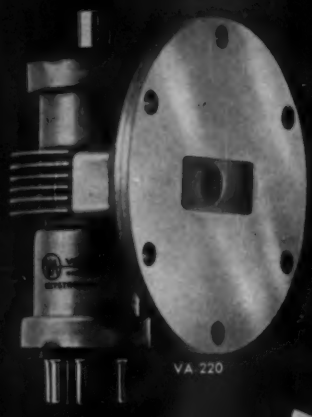

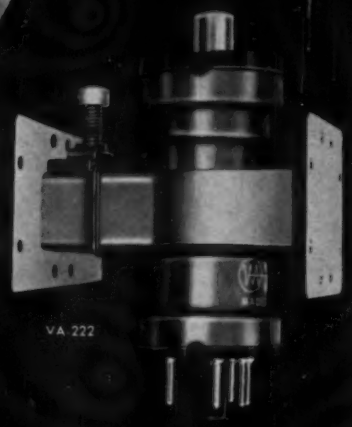

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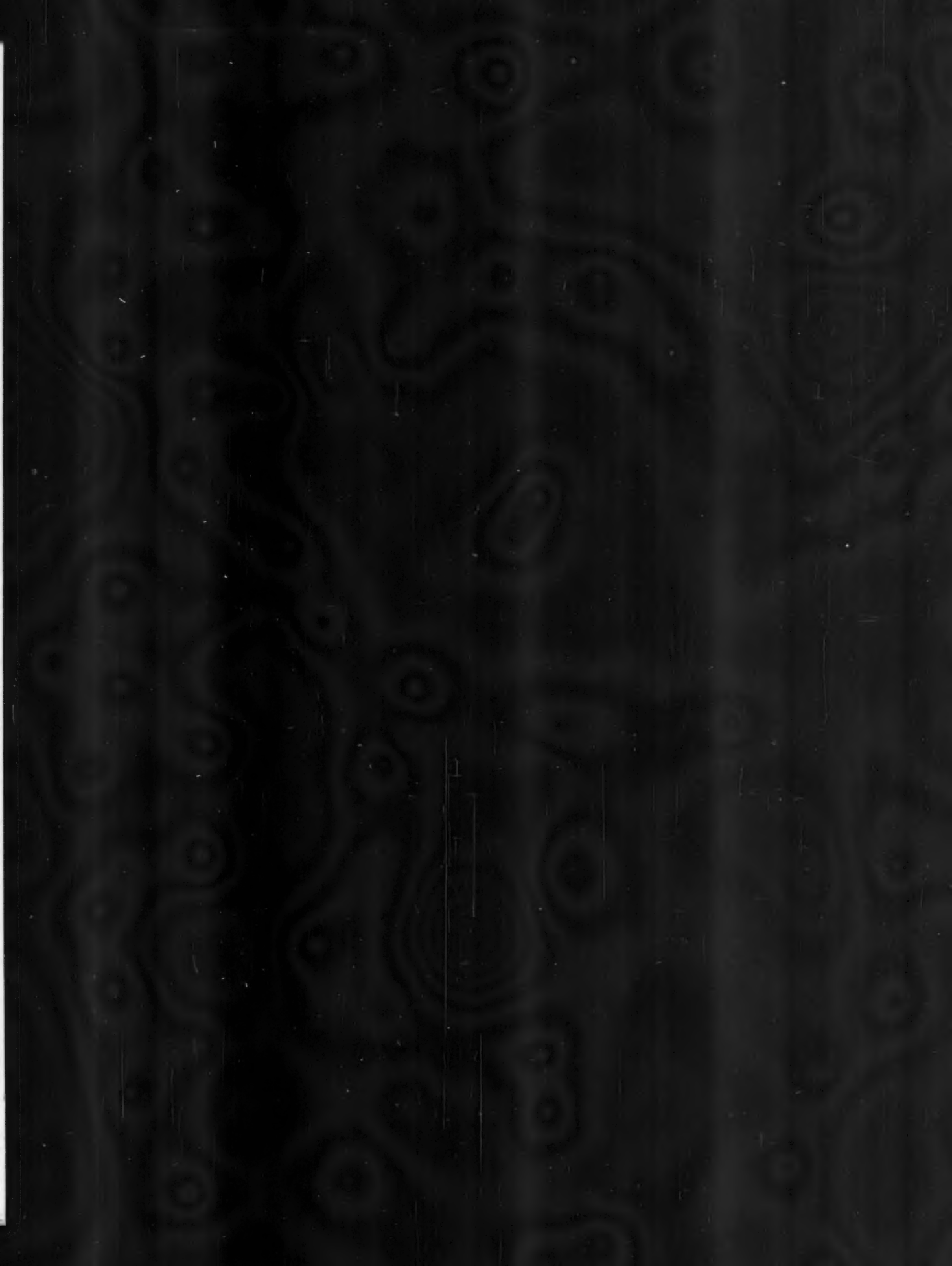
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